North Coast Watershed Assessment Program

Mattole River Water Quality Report

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Evaluation and analysis of Mattole River watershed data will be guided by attempting to answer some key critical questions developed by the North Coast Watershed Assessment Program (NCWAP) participants regarding beneficial uses on a watershed and sub-watershed scale. The key question on which the bulleted questions are predicated is:

What factors are limiting salmonids and macroinvertebrate populations?

- What are the general relationships between land use history (development, timber harvest, agriculture, roads, dams, and diversions) and the current vegetation and level of disturbance in North Coast wateshěds? How can these kinds of disturbances be meaningfully quantified?
- What is the spatial and temporal distribution of sediment delivery to streams from landsliding, bank, sheet and rill erosion, and other erosion mechanisms, and what are the relative quantities for each source?
- What are the effects of stream, spring, and groundwater uses on water quality and quantity?
- What role does large woody debris (LWD) have within the watershed in forming fish habitat and determining channel class and storing sediment?
- What are the current salmonid habitat conditions in the watershed and estuary (flow, water temperature and shade, sediment, nutrients, instream habitat, LWD and its recruitment). How do these compare to desired conditions (life history requirements of salmon, Basin Plan water quality objectives)?
- What are the sizes, distribution, and relative healthiness of populations of salmonids within watersheds?
- Do the current populations and diversity of aquatic communities (especially salmonid fishes, macroinvertebrates, and algae) reflect existing watershed and water quality conditions?

These critical questions laid the groundwork and guidance for data gathering, collection, and assessment procedures by team and individual agency participants. They are addressed in the interagency Mattole Watershed Synthesis Report.

Overview of Water Quality Concerns:

The Mattole River has been placed on a list of water bodies for impairment or the threat of impairment by sediment and temperature as required by Section 303(d) of the Clean Water Act. The 303(d) list describes water bodies that do not fully support all beneficial uses or are not meeting water quality objectives, and the pollutants for each water body that impair beneficial use and water quality. The listing of the Mattole River will eventually result in numeric targets for sediment and temperature allocations being developed by the North Coast Regional Water Quality Control Board (Regional Board) that are expressed as a total maximum daily load (TMDL) for each pollutant.

At the time of the listing sediment and temperature were judged to be impacting the cold (COLD) water fishery and associated beneficial uses, described in the Water Quality Control Plan, North Coast Region, Region 1 (Basin Plan, 1996). Nearly all aspects of the cold water fishery are presumed to be affected by sediment and temperature pollution, including the migration, spawning and reproduction, and early development of cold water fish such as coho and chinook salmon, and steelhead trout.

Other beneficial uses of water in the Basin Plan for the Mattole River include municipal, agricultural, industrial, water contact and non-contact recreation, commercial and sport fishing, wildlife habitat and those plant and animal populations associated with terrestrial ecosystems, as well as similar attributes in estuarine ecosystems. Aquaculture in the Mattole River is also foreseen as a potential beneficial use in the Basin Plan.

The Basin Plan also describes specific water quality objectives for the Mattole River that include limitations for in stream specific conductance, total dissolved solids, dissolved oxygen, and pH or hydrogen ion concentration. If exceedences to specific water quality objectives are discovered during NCWAP data gathering, collection, and analysis they will be elucidated and addressed in pertinent report sections. It should be noted that data were not available or not analysed for all the Basin Plan objectives.

Although numeric targets for a sediment and temperature TMDL have not yet been developed for the Mattole River, much of the following discussion focuses on issues of concern relative to their adoption. Brief references are made to numeric targets adopted for the Garcia River TMDL and, at this time, should not be construed as applicable to the Mattole River.

Key Regional Water Board findings, summarized below, disclosed that the Mattole River and many of its tributaries are influenced by the following:

- Temperatures are above acceptable limits and likely impacting the salmonid fisheries and other beneficial uses of water in the estuary and the mainstem up to the Southern Subbasin near river mile (RM) 55. Temperature extremes are also affecting the lower gradient downstream reaches of North Fork (NFK) and Upper North Fork (UNFK) Mattole rivers, Honeydew, UNFK Bear, Mattole Canyon, and Squaw creeks.
- Temperature data is within the optimal conditions for salmonids in many of the upper reaches of the larger tributaries mentioned above. Fish presence data compiled by the California Department of Fish and Game (DFG) and the Mattole Salmon Group (MSG) appear to confirm this conclusion. In some upstream tributaries there was insufficient and/or poorly qualified data to adequately determine temperature conditions in specific tributaries to the Mattole River (such as Oil and Rattlesnake creeks, tributaries to the UNFK Mattole River).
- Temperature may currently be impacting the salmonid fisheries and other beneficial uses of water in some isolated tributaries for an unknown distance upstream from their confluence's with the mainstem (such as Bridge, Lost River, and Westlund creeks). Presently there is insufficient data to properly assess the upstream reaches of these tributaries.
- Sediment is currently impacting the salmonid fisheries and other beneficial uses of water in the estuary, the mainstem up to the Southern Subbasin, and the lower gradient downstream reaches of NFK and UNFK Mattole rivers, UNFK Bear, and Mattole Canyon creeks. Data were insufficient for a conclusive analysis, but sediment may also be detrimentally impacting Squaw Creek. At this time insufficient data is available to assess sediment impacts (or lack of impacts) to many smaller Mattole River tributaries.
- Two sediment metrics (see text) for mainstem Honeydew Creek are within acceptable numeric standards for the Garcia River sediment TMDL. A sediment TMDL has not been established for the Mattole River and the Garcia River TMDL is used as a reference point only.

- Although data were gathered inconsistently spatially, temporally, and volumetrically, it does not appear that water chemistry and basic physical parameters, such as pH, specific conductance, and dissolved oxygen are impacting the salmonid fisheries, other vertebrate species, macroinvertebrates, and floral constituents in the Mattole River watershed. There is evidence that dissolved oxygen may approach anoxia in deeper pools in the estuary; further sampling is needed to confirm or refute this finding. A site above Blue Slide Creek in the Eastern Subbasin suffered a diesel fuel leak that released free product into the stream in early 2000. The site is now being remediated by the responsible party and monitored by the Regional Water Board. Sample analyses during 2001 were non-detectable for diesel fuel and other petroleum hydrocarbons in the receiving waters of Blue Slide Creek (not all objectives and parameters relating to water quality as described in the Basin Plan were measured).
- Herbicide and pesticide residues from commercial timber applications have been anecdotally linked to impacts to water quality. There have been no scientifically conducted sampling efforts in any of the Mattole Subbasins to confirm or refute these observations.

Methods:

Interoffice cooperation:
NCWAP, Surface Water Ambient Monitoring Program (SWAMP), and TMDL staff have cooperated, and will continue to cooperate and interact with each other to gather, collect, and analyze data for all programs tasked to the Regional Water Board. For example, in 2001, TMDL staff placed Onset® thermographs in various watercourses throughout the Mattole basin and NCWAP staff analyzed the compiled raw temperature data to arrive at maximum weekly average temperatures (MWAT) and other temperature information pertinent to both programs. NCWAP and TMDL staff also conducted instream sediment sampling and analysis (particle size distributions, or D50s) in the Mattole basin during 2001.

SWAMP and NCWAP staff jointly participated in two sampling events in the Mattole basin during 2001 to gather basic water chemical and physical data and, if funding is available, anticipate future field sampling. All three involved Regional Water Board units will continue gathering, collecting and analyzing watershed information (both historic and recent) for geologic, land use, fisheries, climate, water resources, and water quality factors that may influence the impairment, and or improvements, to the beneficial uses of water in North Coast watersheds.

Data Gathering and Analysis Protocols:
The following sections are extracted from the Regional Water Board's NCWAP Methods Manual for Water Quality Data Gathering and Analysis for the North Coast Watershed Assessment Program (Methods Manual). Briefly described are the Regional Water Board's methods for gathering information from our files, as well as other agencies, landowners, watershed groups, and other interested parties. As previously mentioned the SWAMP and the TMDL units at the Regional Water Board are coordinating with the NCWAP and will provide new information to be incorporated into this and future assessments. Often our methods are taken directly or are modifications of others' methods and for that reason, the discussions below are essentially summaries, greater detail can be explored by referring to the Methods Manual.

Data Gathering:
Data gathering is the process of compiling existing data from Regional Water Board files, other agency files, and other sources, particularly active watershed groups such as the Mattole Restoration Council (MRC) and the Mattole Salmon Group (MSG). The Regional Water Board has several types of water

quality information sources within its office, all of which will be evaluated for inclusion into a watershed assessment that included timber harvest plan files, water quality monitoring files, grant files, EIRs, and other reports. Sources outside the office include data and reports from other agencies (including water rights and diversion information), watershed groups, landowners, and public interest groups.

As data were gathered, the location and general characteristics of the data were catalogued in computerized databases. Catalogued data included non-water quality information related to the watershed assessment and was made available to the other NCWAP agencies. We focused our energies on the watersheds scheduled for fiscal year 2001-2002, which, in addition to the Mattole River, included Redwood Creek and the Gualala River. However, as we found data from a particular landowner, watershed group, or agency that overlapped into other NCWAP watersheds, we also categorized those data to assist in future data gathering efforts.

<u>Data Collection:</u>
As briefly mentioned above, NCWAP, SWAMP, and TMDL Regional Water Board staff cooperated in collecting physical-chemical data and measurements during 2001 in the Mattole River watershed. Instrument calibration, where necessary, sample collection, and analysis followed protocols described in the Methods Manual. Other collection procedures followed those established by various entities, such as field sample collection guidelines developed by, and/or acceptable to the USEPA and USGS.

Instream surface particle sediment sampling (pebble counts) were conducted in the Western Subbasin in Nooning Creek, and the Southern subbasin in the mainstem Mattole River upstream from Dream Stream, Baker, Bridge, Helen Barnum, Lost River, Thompson, Vanauken, Yew, and Ancestor creeks. Using protocols described by the US Forest Service (Bunte and Abt, 2001) median particle sizes, or D50s, were calculated from the pebble counts by the TMDL unit and shared with NCWAP.

Other sediment data were gleaned from previous efforts, particularly those of the MSG, that included year 2000 residual pool filling, or V* (MSG, 2000). In addition, the DFG conducted stream inventories and habitat typing during 2001, and also in past years, that included the collection of McNeil core samples and estimates of riffle embeddedness. It was agreed that DFG will be analyzing and presenting the data collected from their efforts.

Temperature data were collected by the TMDL unit and analyzed by NCWAP Regional Water Board staff. NCWAP staff also assisted in stream percent shade canopy assessments during 2001 using a Solar Pathfinder®. The TMDL unit also contracted with a consultant to have aerial infrared radar projections capable of assessing shade canopy and surface water temperatures. The Solar Pathfinder® data are presently being analyzed by a technical staff person shared between both units. Only the radar data results were available from the consultant in time for this report.

During 2001, NCWAP and SWAMP staff under the umbrella of the SWAMP, collected basic water column physical measurements that included pH, specific conductance, point-in-time temperature, and dissolved oxygen. Grab water samples were also collected and later analyzed by Sequoia Analytical Laboratory, an EPA approved facility in Petaluma, CA. Analyses included chlorophyll-a, alkalinity, hardness, and total fractions of the following: metals, dissolved solids, organic carbon, and nitrogen. SWAMP sample points included three locations in the mainstem Mattole River near, 1) Petrolia, 2) below the Honeydew-Humboldt County Road Bridge and, 3) at Ettersburg.

Data Analysis and Presentation:

Gathered data were computerized into formats appropriate for the information, e.g., spreadsheets for dissolved oxygen, specific conductance, pH, temperature, etc. Analysis of the data is specific to the data type and its quality. Specific guidelines for temperature and sediment used in this report are outlined below and apply to all Mattole River Subbasins where they are discussed.

Water Temperature:

Water temperature data from continuous recording thermographs were evaluated from raw data plots over time, and cumulative distribution plots against water quality criteria or water quality objectives to determine frequency of exceedances (percent of observations and number of days), duration of exceedances (how many hours was a particular standard exceeded in a day), and maximum daily excursions. Temperature plots derived from maximum weekly average temperatures (MWAT) were also compared to the fully suitable range of conditions, between 50-60 ^{o}F (10-15.6 ^{o}C), that are agreed as optimal for various salmonid life stages. The 50-60 ^{o}F range was developed as an average of the needs of several cold water fish species, including coho salmon and steelhead trout. As such, the range does not represent fully supportive conditions for the most sensitive cold water species, usually considered to be coho salmon (Armour, 1991; Forest Science Project, 1998). In addition, stream water temperature ranges of varying suitablility to unsuitablility above the 50-60 ^{o}F fully suitable MWAT range for salmonids were developed by the NCWAP Team; the breakdowns for all MWAT ranges are:

50-60 ^{o}F	"fully suitable"
61-62 ^{o}F	"moderately suitable
63 ^{o}F	"somewhat suitable"
64 ^{o}F	"undetermined"
65 ^{o}F	"somewhat unsuitable"
66-67 ^{o}F	"moderately unsuitable"
=68 ^{o}F	"fully unsuitable"

Maximum weekly average and peak temperature plots were also derived from summary data provided by the MSG for the years 1996 through 2000, and from raw thermograph data for 2001. The 2001 raw temperature data provided by the MSG, and also the Regional Water Board's 2001 data were analysed using the KRIS temperature utility.

Peak temperatures are also important to consider as they may reflect short term thermal extremes that, unless salmonids are able to escape to cool water refugia, may be lethal to fish stocks. The literature supports a critical peak lethal temperature threshold of 75 ^{o}F (24 ^{o}C), above which death is usually imminent for many Pacific Coast salmonid species (Brett, 1952; Brungs and Jones, 1977; RWQCB, 2000; Sullivan, et al., 2000).

During 2001 the DFG also placed thermographs in fifteen Mattole River tributaries, however, the data gathering period began during mid-August and, in three instances, as late as early September. The analyses of DFG's raw thermograph data were done by the Regional Water Board with the assistance of the KRIS Hobo Utility. In all cases, the daily and weekly temperature plots were on the decline from seasonal high temperatures when compared to temperature plots for a full summer reporting period, generally from mid-May through mid-October (MSG, 2001; Regional Board, 2001). One DFG sample point in Honeydew Creek was not analysed due to a thermograph failure (DFG, 2001). Because the DFG temperature data did not meet Forest Science Project and NCWAP protocols it should be used for informational purposes only. Also, because the DFG's temperature results are not comparable to those gathered and analysed over an entire sampling season the results are discussed under a separate subheading in the temperature sections for each subbasin.

<u>Sediment Analysis:</u>
Turbidity and suspended sediment: Turbidity data were irregularly collected by the DWR and, when it was sampled, consisted of a single grab sample collected at the USGS Petrolia gaging station on a specific date. Available records do not indicate suspended sediment sampling was conducted in the Mattole River Basin. Such inconsistent sampling provides little useful data to assess impacts to the cold water salmonid and other beneficial uses in the Mattole River. Turbidity and suspended sediment numeric water quality objectives, in addition to those already in the Basin Plan (see Table 1), are being considered for inclusion in the Basin Plan at targets yet to be determined, above which there may be harmful effects to optimal salmonid growth and survival. We recommend that in the future, turbidity, suspended sediment, and streamflow rating curves be developed so as to enable a more accurate assessment of water quality beneficial to the health of salmonid populations in the Mattole River Basin.

Vstar: This abbreviated discussion of Vstar (V*) is applicable to all subsequent references in subbasins where V* is discussed. V* is the fraction (percent) of residual pool volume filled with fine sediment (silt, fine sand to small- to medium-gravel). It can be used as one of many indicators of the sediment supply and substrate habitat in gravel bed channels. It has proven to be a useful tool to evaluate and monitor stream channel conditions and determine ustream and upslope sediment sources (Knopp, 1993; Hilton and Lisle, 1993). For the North Coast, Knopp divided drainages into disturbance categories; undisturbed reaches are those with no known land use disturbances, and were designated as index no. An index yes category included drainages with evidence of land use disturbance greater than approximately 40 years ago. Index yes reaches showed significant recovery from the effects of past land use disturbances. Two more categories, moderately disturbed and highly disturbed watersheds, were also designated, based on geologic stability and degree of land use disturbance and/or recovery. To arrive at V* values for a stream Knopp measured the residual pool volume of six pools per reach and calculated the average V* for the combined pools (Knopp, 1993).

For the Garcia River TMDL, Knopp's V* results from the index yes and index no reaches were averaged together to calculate a numeric mean V* =0.21 for six pools, and maximum V* =0.45 for the highest value for an individual pool out of a set of six sampled pools. A TMDL target for V*, if one is adopted for the Mattole River sediment TMDL, has not been determined at this time and the preceeding discussion for the Garcia River is meant only to provide a frame of reference for V* results determined in the Mattole River drainage. The Garcia River TMDL was chosen as a reference point because a quorum of the Regional Board, and also the State Water Resources Control Board have adopted the numeric sediment targets for the Garcia River (Regional Water Board, 1997). The Garcia River numeric targets have not yet been amended into the Basin Plan and should not be construed as regulatory targets for the Mattole River. To assist in determining relative rates of residual pool filling a further breakdown of of V* values, derived from Knopp's 1993 report, are itemized below:

V* = 0.30 = low pool filling; correlates well with low upslope disturbance
V* > 0.30 and = 0.40 = moderate pool filling; correlates well with moderate upslope disturbance
V* > 0.40 = High (excessive) rates of pool filling; correlates well with high upslope disturbance

The MSG collected V* at eight locations throughout the Mattole watershed during 2000. They calculated an reach-averaged V* for the number of pools sampled using a weighting factor specific to that reach, designated as V*w. Knopp also calculated V* as V*w during analysis of field data for residual pool volumes. Both the MSG's and Knopp's V*w results are based on the methodology used by Hilton and Lisle (Hilton and Lisle, 1993) and, therefore, are comparable to each other when used in stream reaches with similar hydrologic and geologic characteristics, such as those in the Mattole River basin.

D50 (median particle size): Pebble counts determining the median particle size, or D50, have long been used by hydrologists, geomorphologists, and others to characterize streambed material particle size distributions, usually in riffles, of wadable, gravel-bed streams. The pebble count procedure has been adopted in fisheries studies as a preferred alternative to visually characterizing surface particle sizes of riffles (Bundt and Abt, 2001; Kondolf and Li, 1992).

Knopp also calculated D50 values for combined index yes and index no drainages that were derived from three riffles measured for each stream reach. A mean D50 >69 mm, and a minimum D50 =37 mm were calculated for both reach categories. These values were adopted as numeric targets for the Garcia River TMDL for third order streams as protective of the COLD beneficial use of water. A TMDL numeric target for D50 has not been determined for the Mattole River; the Garcia River mean D50 >69 mm is referenced in subsequent sections for discussion purposes only (Regional Water Board, 1997). Whether a particle-pebble is mobilized or retained on a riffle is very much dependent on the riffle gradient. Because of the geomorphic variability that can exist between any population of riffles in the same sample reach the minimum D50 =37 mm established for the Garcia River will not be referenced in this report.

Additionally, a modeling program, the Ecological Management Decision Support (EMDS), is a knowledge-base expert system that will be used to evaluate sound data gathered and collected during NCWAP research. This system takes the data gathered for the watershed and, through a series of logic trees, evaluates the data with respect to watershed factors to assist in representing areas that are supportive of salmonids, and those that are not. The two components of EMDS are 1) graphic diagrams of networks, which show relationships between the environmental factors and conditions for salmon; and 2) the physical and biological data from the watershed. The diagrams are intended to be explicit and intuitive, and to communicate the process used in the synthesis in an understandable manner. It should be noted that V* numeric thresholds were not adopted for use in the EMDS model. The EMDS model sequentially chooses from percent fine sediments (e.g. McNeil core samples), pool tail embededdness, and pebble counts or D50s to evaluate substrate composition suitability for salmonid spawning. The EMDS is explained in greater detail in the interagency Mattole Watershed Synthesis Report and is referred to in this document where applicable.

Table 1, below, summarizes key points from the preceding discussions. The water quality-chemistry analysis included comparison of available data to water quality objectives from the Basin Plan, Total Maximum Daily Load suggested targets from the Garcia River TMDL, and EMDS dependency relationships (thresholds) and other ranges and thresholds derived from the literature. With the exception of the Basin Plan objectives, these ranges and thresholds and are not legal regulatory numbers. Rather, they are based on information available at the time and are expected to change as new data and analyses become available.

Table 1. In-channel criteria used in the assessment of water quality data.

Water Quality Parameter	Range or Threshold	Source of Range or Threshold
pH	6.5-8.5	Basin Plan, p 3-3.00
Dissolved Oxygen	7.0 mg/L	Basin Plan, p 3-3.00
Temperature	No alteration that affects BUs [1]	Basin Plan, p 3-3.00
	No increase above natural > 5 F	Basin Plan, p 3-4.00

Water Quality Parameter	Range or Threshold	Source of Range or Threshold
	50-60 F MWAT [2] – fully suitable	EMDS Fully suitable Range [3]
	75 F daily max (lethal)	Cold water fish rearing, RWQCB (2000), p. 37
Sediment Settleable matter	not to cause nuisance or adversely affect BUs	Basin Plan, p 3-2.00
Suspended load	not to cause nuisance or adversely affect BUs	Basin Plan, p 3-2.00, 3-3.00
Turbidity	no more than 20 percent increase above natural occurring background levels	Basin Plan, p 3-3.00
Percent fines <0.85 mm	<14% in fish-bearing streams [4]	Garcia TMDL, (1997)
Percent fines <0.85 mm	≤10% - fully suitable	EMDS
Percent fines <6.4 mm	<30% in fish-bearing streams	Garcia TMDL (1997)
Percent fines <6.4 mm	≤15% - fully suitable	EMDS
V* in 3rd order streams with slopes 1-4 % [5]	≤0.21 (mean) <0.45 (max)	Garcia TMDL (1997)
Median particle size (d_{50}) in 3rd order streams of slopes 1-4 %	>69 mm (mean) >37 mm (min)	Garcia TMDL (1997), Knopp (1993)

[1] BUs = Basin Plan beneficial uses

[2] MWAT=maximum average weekly temperature, to be compared to a 7-day moving average of daily average temperature

[3] EMDS = Ecological Management Decision Support model used as a tool in the fisheries limiting factors analysis. These ranges and thresholds were derived from the literature and agreed upon by a panel of NCWAP experts.

[4] fish-bearing streams=streams with cold water fish species

[5] V* is the percentage of residual pool volume occupied by sediment depositions

CDFG=Calif. Department of Fish and Game habitat threshold

Analysis and Results by Subbasins

Estuary and Mainstem Mattole River:

Conditions in the estuary are, for the most part, defined and driven by all that occurs in upstream reaches of the mainstem and its tributaries. For this reason, and also because it forms the dividing line between many of the NCWAP Subbasins, information pertinent to the the length of the Mattole River mainstem through the headwaters are combined in this section

Water Chemistry and Quality:
For the mainstem of the Mattole River general water chemistry information was available in summary form from data collected at the USGS gaging station near Petrolia by the Department of Water Resources (DWR) for discontinuous water years from 1974 through 1988, and were available as DWR Water Quality Records (DWR, 1979). Archives were also available in the US Environmental Protection Agency, STORET (STORET) LDC Data Reports (STORET, 1988). For any period of record a water year encompasses sampling dates from October 1 of one calendar year to September 30 of the next calendar year.

For water years 1974 through 1979, the DWR collected point-in-time samples that included specific conductance, pH, temperature, turbidity, dissolved oxygen, hardness as calcium and magnesium carbonate (Mg-$CaCO_3$), and a suite of other chemical groups, such as bicarbonate and non-carbonate hardness. Ionic constituents were also measured that included dissolved sodium, chloride, and boron. The data for the five-year period has limited usefulness for developing long term trend analysis as sampling was inconsistently collected. For example, for the entire period of record, five samples were collected in February, one in April, three in September, and two in October.

The STORET database also included physical water quality measurements collected by the DWR from February, 1982 through June, 1988. Parameters measured included the most commonly collected, basic field metrics of temperature, turbidity, specific conductance, dissolved oxygen, and pH. Sampling periods were concentrated in February, April, June, September, and October with six, three, one, two, and four collection periods, respectively. Turbidity, measured as Formazin turbidity units (FTU) as expected, rose and fell with rising river discharge during the February 1975 rainy season when it reached a high of 400 FTUs, and were as low as one FTU during low flow periods in June, October, and September. FTUs are comparable to the more familiar nephalometric turbidty units, or NTU. Again, as above, trends and predictions are difficult to infer from the STORET-DWR records due to discontinuous, inconsistent sample collection.

An instantaneous grab sample by the DWR on September 5, 1979 had a pH of 8.6, this exceeded the Basin Plan numeric target for the Mattole River pH = 8.5. For all other sample years the pH was below the maximum numeric target and above the minimum numeric target for pH =6.5 in the Basin Plan for the Mattole River. In general, the pH in the Mattole River conforms to the Basin Plan targets that are supportive of the beneficial uses of water.

The following figures represent pH, dissolved oxygen, and specific conductivity extracted from data for the above sampling periods.

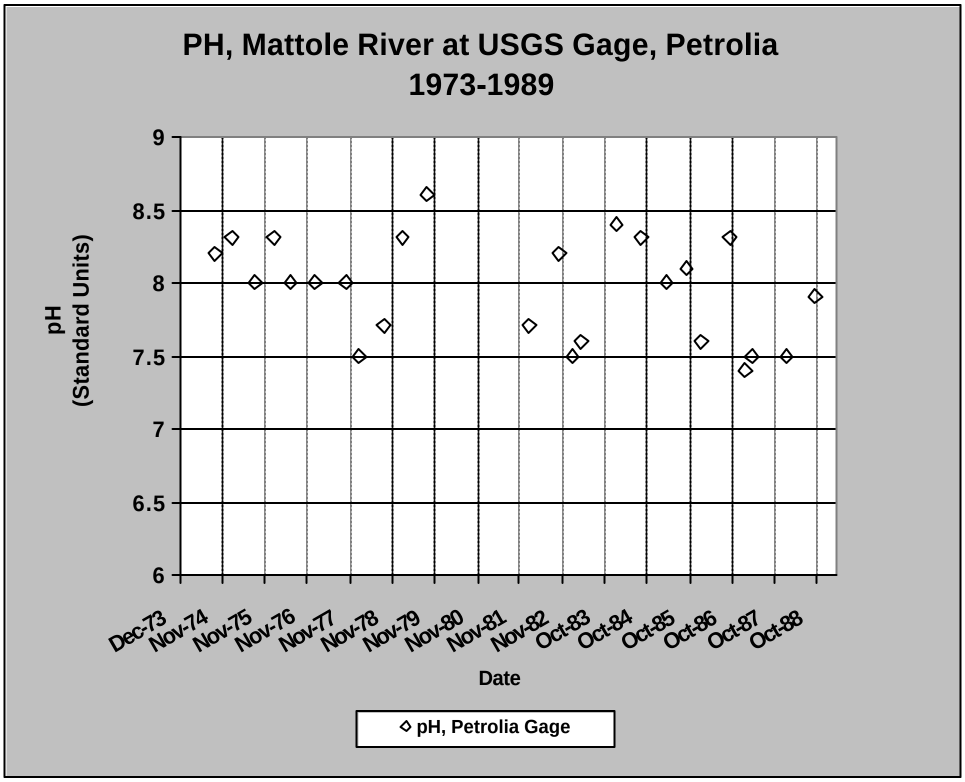

Figure 1. PH, Mattole River at the USGS Petrolia gage, 1973-1989.

The pH measures the relative acidic or basic properties of a waterbody, or other solutions, with a pH of 7 equal to neutral. The Mattole River during the sampling period of record had pH values that were above neutral but, in general, are supportive of the cold water fishery at the reach of the river near the USGS gaging station.

On April 20, and May 17, 2001, the Regional Water Board under the SWAMP collected water samples for later analysis along with commonly measured field data that included pH, dissolved oxygen, specific conductance, and point-in-time temperature. Mainstem sampling took place at the Mattole River bridge near Petrolia, the Honeydew Bridge, and at Ettersburg. Sampling also took place in the NFK Mattole River immediately upstream from its confluence with the mainstem.

Specific conductance, as Figure 2 shows during the periods sampled by DWR, were fairly typical of that expected in most rivers and streams in the North Coast of California and did not exceed numeric target thresholds in the Basin Plan established for the Mattole River.

Specific conductance is the ability of a water sample or solution to carry an electrical current and is a general measure of ionic constituents in solution such as sodium, chloride or other electrically charged particles. Conductance increases as the concentration of ions increases. Seawater would have very high specific conductance values as opposed to river water. The above chart for the Mattole River at the USGS Petrolia gage shows a decrease in conductance during winter sampling periods, when high water flows from runoff dilutes ionic concentrations, and an increase during late summer when very little runoff occurs.

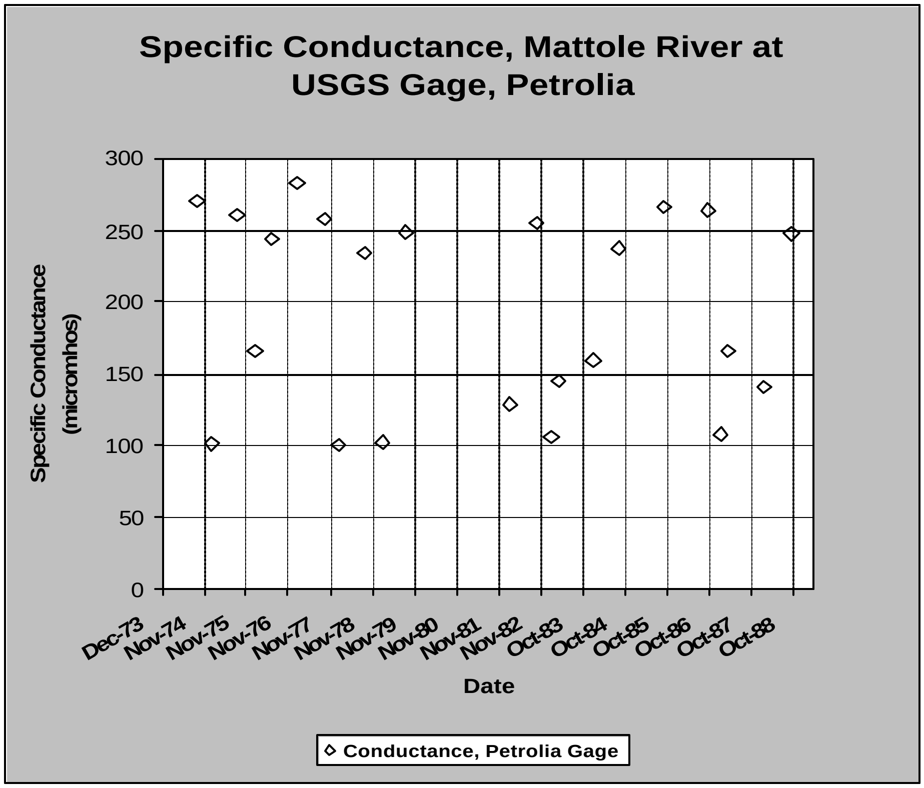

Figure 2. Specific conductance, Mattole River at the USGS Petrolia gage, 1973-1988.

Figure 3, below, are dissolved oxygen values collected by the DWR during the same sampling periods that specific conductance and pH were measured. None of the values dropped below numeric target thresholds for dissolved oxygen established for the Mattole River in the Basin Plan.

Dissolved oxygen levels for the Mattole River at the USGS Petrolia gage were generally high during all seasons sampled. These values are well suited to the viability of the cold water salmonid populations present in the Mattole River at this reach of the river.

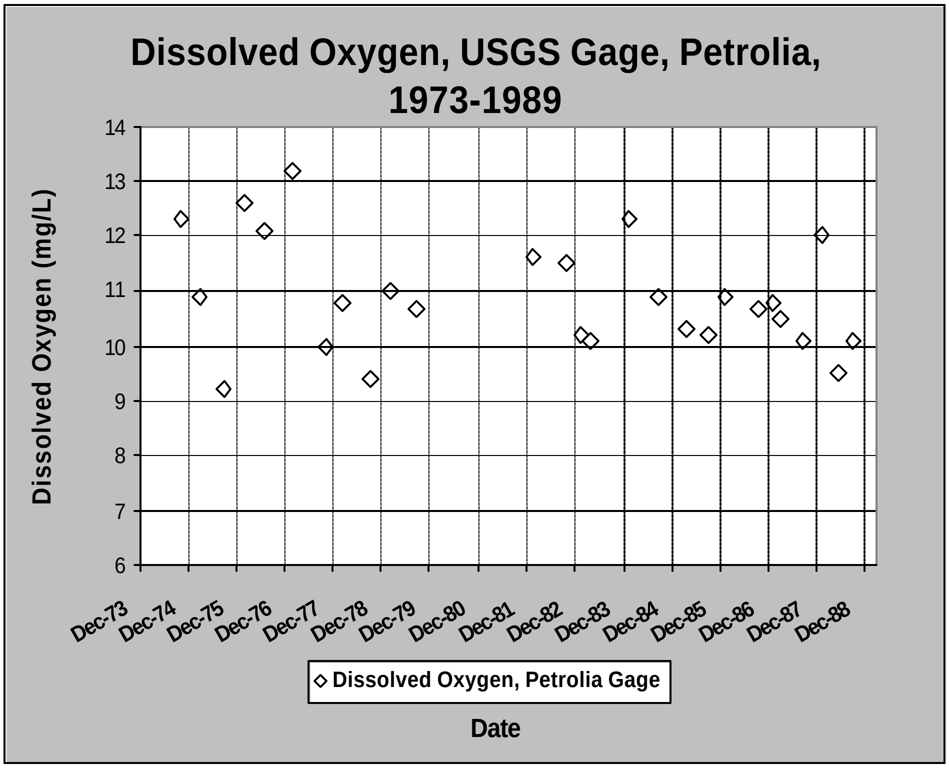

Figure 3. Dissolved oxygen, Mattole River at the USGS Petrolia gage, 1973-1988.

All the above data and analyses by the involved agencies during the limited sampling periods indicate a low to moderately hard water, oligotrophic waterbody with pH's slightly above normal, high dissolved oxygen, and low dissolved solids.

Water quality in the estuary varies seasonally depending on river discharge. From mid- to late summer decreasing river discharge and seasonally shifting ocean currents promotes sand bar formation, eventually isolating the river mouth from the Pacific Ocean. When the sandbar is in place tidal and river exchanges no longer occur, resulting in lagoon conditions in the lower river, affecting water quality differently compared to estuarine conditions. The MRC estuary assessment, Dynamics of Recovery, and other researchers mention that possible drops in dissolved oxygen leading to anoxic conditions may be associated with the growth and decay of extensive algal mats during low river flows and lagoon conditions (MRC, 1995; Young, 1987; Busby, et al., 1988; Zedonis, 1992). During lagoon conditions, Busby, et al., using depth integrated sampling, measured dissolved oxygen approximately 104 times at four different stations from May through November, 1997. At three stations dissolved oxygen dropped below the Basin Plan minimum of 7.0 ppm on six occasions. Evidence that anoxia is approached were observed during the night of September 9, 1987 when, approximately 1,000 feet from the Pacific Ocean at a depth of 4.9 feet, a dissolved oxygen level of 2.8 ppm was measured; the depth-to-bottom at the monitoring location was 6.6 feet. Also at night at the same location, and at another adjacent to the sandbar between the river and the ocean on November 13, 1987, dissolved oxygen levels were also very low at 4.7 ppm and 5.2 ppm, respectively (Busby, et al., 1988). Similar depressed dissolved oxygen conditions, also location dependent, have been documented in the Russian River estuary during periods of mid- to late summer bar closures of the river mouth (Goodwin, et. al, 1993). True anoxic conditions, with dissolved oxygen levels at 0.0 mg/l, in the Russian River estuary were typically associated with pools as deep as 35 to 40 feet. The Mattole Estuary-Lagoon did not appear to be deeper than 12 feet at transects sample by the MRC (MRC, 1995), and was a maximum of 9.8 feet at the four sites monitored by Busby during the 1987 sampling period (Busby, et al., 1988).

If widespread anoxic conditions are prevalent during low flow, lagoon conditions, any salmonid populations residing there, such as outmigrating chinook salmon or steelhead, may be suffocated if adequately oxygenated escape refugia is not available. Except locally, as documented by Busby, et al., all studies to date indicate that widespread, anoxic conditions do not exist. To ascertain if widespread chronic, anoxic conditions develop in association with bar closure, a rigorous sampling procedure that includes additional depth integrated sampling at the locations of specific pools and transects would be necessary. Of more concern, addressed below, are that uniformly aggraded, shallow conditions in the lower river are harmfully affecting salmonid populations during lagoon conditions by contributing to unsuitable and, at times, lethal temperature extremes.

Sampling throughout the year would also be informative to determine the distance upstream that salt water intrudes during river mouth openings. Evidence is presented in MRC's estuary assessment indicating that tidal influences and salt water intrusion occur during low flows as far as 0.89 miles upstream (MRC, 1995). The presence of salt water is vital to the smoltification of downstream migrant salmonids, particularly chinook salmon, prior to entering the ocean environment.

<u>Water Temperature:</u>
Summary temperature records for the Mattole basin from 1996-1999 obtained from remote, continuously recording thermographs (thermographs) were furnished to the Regional Water Board for additional analysis by the MSG as Excel database files (MSG, 2001). Year 2001 raw thermograph data were also provided by the MSG and, as previously mentioned, was analysed with the KRIS temperature utility. Year 2000 MSG raw data was also available but time constraints prevented adequate analysis for inclusion in this report. In addition to MSG monitoring points, the Regional Water Board placed thermographs at twenty locations in the Mattole watershed during 2001, including three in the mainstem Mattole River. From the continuous daily temperature records MWATs were calculated and, as mentioned previously, reflect the highest floating weekly average temperatures for the summer recording periods, which often extended to the middle of October. Peak maximum summer temperatures were also extracted from the available databases, and also the raw data from thermographs deployed by the Regional Water Board. Temperature locations along the Mattole River mainstem are depicted in Figures 26-29, Maps 1-4 under each individual subbasin.

Table 2 displays peak MWATs for the mainstem Mattole River beginning at an unnamed "Headwater" tributary at RM 61, continuing downstream toward the Pacific Ocean. For clarification all river miles are measured from the confluence of the Mattole River Estuary with the Pacific Ocean. Except for locations in the mainstem near Dream Stream, McNasty Creek, and the "Headwaters" at RMs 59.4, 60, and 61, respectively, all other MWATs were above the threshold range of 50 ^{o}F-60 ^{o}F that is considered optimal for healthy, viable salmonid populations. Again, as previously mentioned, this range does not represent fully suitable conditions for the most sensitive cold water species, usually considered to be coho salmon. The mainstem site downstream from McNasty Creek exceeded the optimal MWAT range during 1997, 1998 and 1999. What is interesting is that salmonids, particularly chinook salmon and steelhead, are known to use portions of the lower mainstem and the estuary for smoltification prior to entering the Pacific Ocean (MRC, 1995; Young, 1987; Zedonis, 1992). In all likelihood, salmonids are able to access cold water refugia as an avoidance strategy for survival during periods of time when they are residing at locations in the mainstem with elevated temperature extremes (see Mill Creek discussion below).

Table 2. Maximum weekly average temperatures, mainstem Mattole River, headwaters to the Pacific Ocean, 1996-2001.

River Mile	"Major" Upstream Watercourse	MWAT (F) 1996	MWAT (F) 1997	MWAT (F) 1998	MWAT (F) 1999	MWAT (F) 2001
0.1	Estuary-Stansberry Cr			70.6	68.2	
0.5	Estuary-Stansberry Cr (7ft deep)					73.4
0.5	Estuary-Stansberry Cr					70.7
1	Mill Cr			71.5	69.4	
2.9	NFK Mattole (surface)					72.2
2.9	NFK Mattole (5-6ft deep)					67.3
3	NFK NFK Mattole			72.7	69.9	72.3
3.3	NFK NFK Mattole					68
3.5	Conklin Cr					71.5
6.2	Conklin Cr					72.4
6.2	Conklin Cr					72.3
14.5	Squaw Cr (surface)					72.9
14.5	Squaw Cr (5-6ft deep)					69.8
15.5	Pritchett Cr	73.6		73.9		
25.2	UNFK Mattole					73.3
26.4	Honeydew Cr			71.7	69.8	
40.6	Mattole Cyn Cr	75.8				
42.9	Big Finley Cr		74.4		70	73
47.3	Big Finley Cr (surface)					66.6
47.3	Big Finley (9-10ft deep)					61.9
47.7	Nooning Cr			71.1		
50.7	Bridge Cr	68.7	67.6	67.4	66.6	
52.7	McKee Cr (surface)					64.9
52.7	McKee Cr (5-7ft deep)					62.5
53.9	Vanauken Cr					65
56.5	Gibson Cr		64.1	64.2	62.4	
56.7	Gibson Cr (surface)					61.7
56.7	Gibson Cr (5-6ft deep)					61.8
59.4	Dream Stream					57.9
60.8	McNasty Cr		64.1	60.8	60.1	58.5
61.0	Headwaters-Lower	55.4				
61.2	Headwaters-Upper	52.7				

Figure 4 is a graphical representation of the peak MWAT values in Table 2 for the mainstem Mattole River from the mouth of the estuary at approximately RM 0.1 to the headwaters at RM 61.2

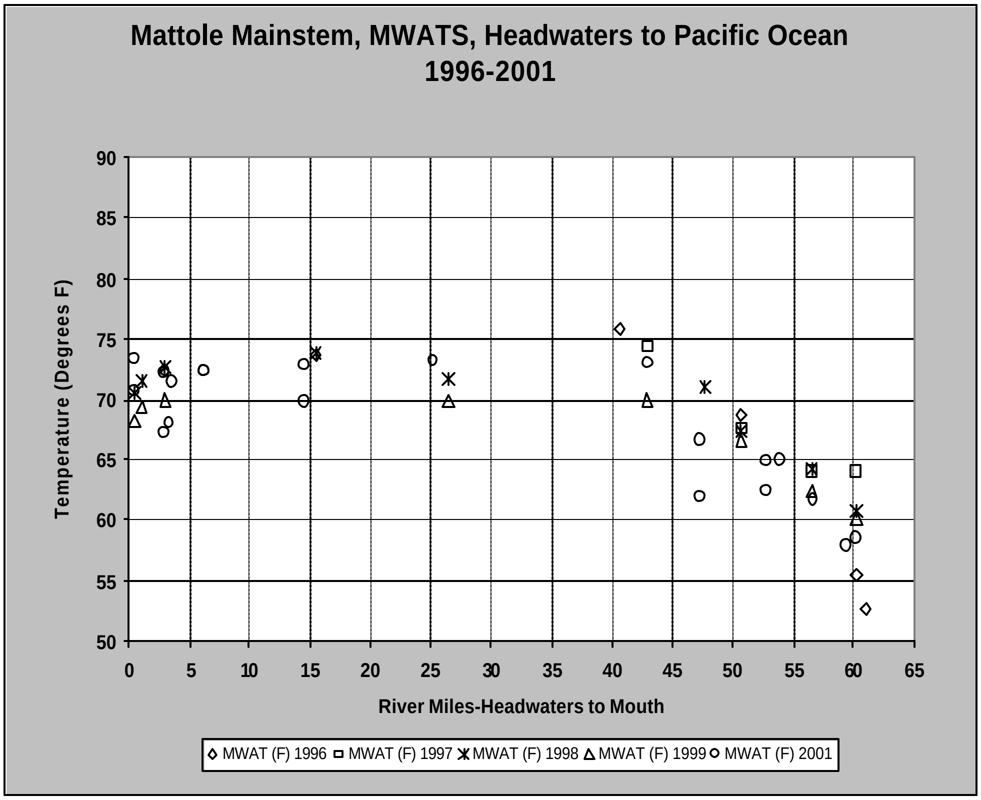

Figure 4. Maximum weekly average temperatures, Mattole River, headwaters to the estuary, 1996-2001.

The data show there is a clear trend for MWATs in the low 50 ^{o}F to mid- 60 ^{o}F range, beginning at the Mattole headwaters near RM 60, that continue increasing near RM 40 to over 75 ^{o}F. Temperatures then stabilize in a downstream direction to approximately RM 27 after which they begin to drop slightly approaching RM 15. Further downstream near Mill Creek close to RM 3, and approaching the Pacific Ocean, temperatures continue dropping slightly with MWATs for 1999 that hover at or slightly below the 70 ^{o}F range. At the same locations during 1998 they are a couple of degrees above 70 ^{o}F.

Although not conclusive from the above MWAT distributions, it may be hypothesized that two factors are possibly affecting the progressive downward trend of the MWATs below RM 27, and particularly below RM 5; 1) from the mouth of the estuary to approximately RM 15, the moderating influence of cooler marine air may help stabilize, or to some extent, decrease MWATs in this reach of the mainstem and, 2) it is possible that additional cooling in the mainstem may be influenced by colder stream discharges from nearby tributaries, particularly lower Mill Creek and Stansberry Creek.

The Mill Creek Watershed Analysis (BLM, 2001), states that Mill Creek may be one of the critical, cool water inputs to the Mattole Estuary during periods of low river flow, such as occurs during mid- to late summer. For example, Mill Creek at RM 2.8 never showed MWATs higher than 58 ^{o}F during any recording year. Downsteam from Mill Creek, Stansberry Creek was slightly warmer, with MWATs that approached 64 ^{o}F during 1998, but were in the 58 ^{o}F range during other sampling years.

Records for the mainstem Mattole at the Petrolia USGS gaging station have documented discharges as low as 15 cubic feet per second (cfs) during the months of August and early September (DWR, 1974, 1989). Mill Creek experienced flows anywhere from 10 cfs, to as low as 2-3 cfs during summer low flow periods (BLM, 2001). The estuary enhancement study by the MRC also notes that colder pockets of water were detected in the mainstem at confined areas near the confluence's of five tributaries:

Collins Gulch, Bear, Stansberry, Titus, and, Mill creeks. Mill Creek in 1994 sustained base flows at 2.8 cfs throughout the summer which is much higher than the other four tributaries. For example, Stansberry Creek at 0.2 cfs had the next highest summer base flow. The above low flows in Mill Creek were within a high of 66% and dropped to approximately 13-20% of recorded discharges for the mainstem Mattole River at the Petrolia gaging station. Whether the coastal marine influence coupled with the cooler base flow discharges from Mill Creek can adequately mix with warmer mainstem waters to sufficiently cool the mainstem, as shown in the included temperature records, is hypothetical at this time. It would be informative to further study thermal discharges from tributaries that discharge into and above the estuary to confirm or refute this hypothesis.

Peak maximum temperatures in lower reaches of the mainstem and the estuary exceeded the lethal, short term temperature extreme of 75 ^{o}F for salmonids. Evidence for this was never more clear than when a die off of juvenile chinook was observed in 1987 in the estuary after a peak temperature of ~79 ^{o}F was reported (MSG, 1995). Habitat surveys conducted by the MRC (MRC, 1995) in lower river reaches and the estuary describe the lack of shelter, cover, and cold water refugia available for escape during periods of extreme thermal conditions by salmonids when they are present in the estuary. Also, specific channel cross sections measured in the estuary by the MRC reveal a very shallow body of water, possibly due to sediment aggradation over time from a combination of upstream natural and anthropogenic influences. The shallow estuarine waters would allow solar radiation to more fully penetrate the water column, possibly resulting in elevated water temperatures that are detrimental to populations of fish and other aquatic species.

The following chart of maximum summer temperatures along the mainstem Mattole River, proceeding from the estuary to headwater reaches, as expected, has a similar slope to the MWAT values described above. Peak temperatures below the headwater reaches beginning at RM 47.7 vary, but are mostly well above 75 ^{o}F, reaching a high of 85 ^{o}F. Table 3 is included to easier reference river miles to specific locations portrayed in Figure 5.

Except for a 72 ^{o}F reading during 1996 downstream from Little Finley Creek, and 1996 and 1997 downstream from Nooning Creek, and also 1998 at the river mouth when a 73 ^{o}F peak temperatures were recorded, it is clearly evident that all other recording stations downstream from RM 47.4 exceeded the critical peak lethal temperature threshold of 75 ^{o}F that can lead to imminent salmonid stress and mortality. These high temperatures in this reach of the Mattole River mainstem are not supportive of the COLD beneficial uses of water. A temperature TMDL for the Mattole River has not been adopted yet and it would be premature to compare these high temperatures in the Mattole River to a speculative, future TMDL numeric target.

Table 3. Maximum summer temperature, mainstem Mattole River, headwaters to the Pacific Ocean, 1996-2001.

River Mile	Major Upstream Watercourse	MAX (F) 1996	MAX (F) 1997	MAX (F) 1998	MAX (F) 1999	MAX (F) 2001
0.1	Estuary-Stansberry Cr	83		73	76	
0.5	Estuary-Stansberry Cr					79
0.5	Estuary-Stansberry Cr (7ft deep)					82
1	Mill Cr	83		78	79	
2.9	NFK Mattole (surface)					83
2.9	NFK Mattole (5-6ft deep)					76

River Mile	Major Upstream Watercourse	MAX (F) 1996	MAX (F) 1997	MAX (F) 1998	MAX (F) 1999	MAX (F) 2001
3	NFK Mattole	79	78	81	81	
3.3	NFK Mattole					72
3.5	NFK Mattole					82
6.2	Conklin Cr					81
7.5	Conklin Cr					80
14.5	Squaw Cr	80				83
14.5	Squaw Cr					73
15.5	Pritchett Cr	82	85	80	80	
25.2	UNFK Mattole					82
26.4	Honeydew Cr	78	78	78	81	
40.6	Mattole Cyn Cr	81	81			
42.9	Big Finley Cr	72	82	82	82	79
47.4	Big Finley Cr (surface)					72
47.4	Big Finley Cr (9-10ft deep)					64
47.7	Nooning Cr	73	73	80	80	
50.7	Bridge Cr	76		65		
52.7	McKee Cr (surface)					70
52.7	McKee Cr (5-7ft deep)					64
53.9	Vanauken Cr	57	64	60		69
56.5	Gibson Cr	62	68	67		
56.7	Gibson Cr (surface)					66
56.7	Gibson Cr (5-6ft deep)					65
59.4	Dream Stream					63
60.8	McNasty Cr		68	62	62	
61.0	McNasty Cr	57				64
61.2	Headwaters-Upper	53	60			

Moving upstream along the mainstem, higher temperatures may be partially attributed to the geomorphology of the river channel as it migrates and widens across the flood plain. Because of the latter, a more open channel configuration is apparent from the estuary to around RMs 45 or 50. Above RMs 45-50 the mainstem flows through more incised, confined canyons, with higher canopy closures up to the headwater reaches where, because of less solar radiation reaching surface waters, the temperatures begin dropping below 70 ^{o}F, to around the mid-fifty to sixty degree range at RM 60.

Also, as covered in discussions of the individual subbasins, thermal inputs from a number of major tributaries in lower to mid- river reaches are also very high, with MWATS during certain years, e.g. Honeydew Creek, reaching 78 ^{o}F. The combination of a more open, meandering channel, coupled with excessively high temperature inputs from tributary reaches, all contribute to detrimentally influence water temperatures in the middle to lower reaches of the mainstem Mattole.

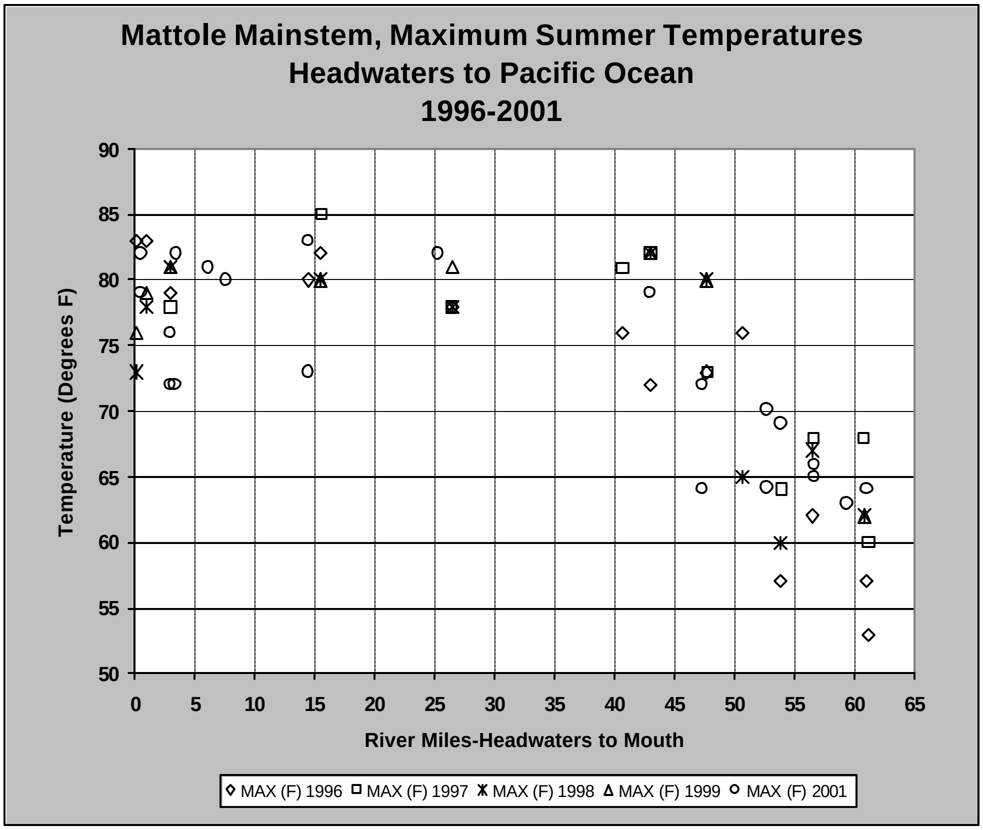

Figure 5. Maximum summer temperatures, headwaters of the Mattole River to the estuary, 1996-2001.

It should be noted that for six locations at RMs 0.5, 2.9, 14.5, 47.3, 52.7, and 56.7, paired thermographs were placed by the MSG during 2001, one just below the water surface and the other at subsurface depths that varied between 5-10 feet, depending on the location (MSG, 2001). For the six locations, MWATS were 0.1 ^{o}F to 4.9 ^{o}F colder, and maximum temperatures were 1 ^{o}F to 9.5 ^{o}F colder for the thermographs placed at depth compared to surface temperatures. None of the MWATs at the paired thermograph locations were protective of the fully supportive range of 50-60 ^{o}F for salmonids, particularly coho salmon.

In contrast to the MWATs, maximum temperatures at the paired thermograph locations for the upper river reaches at RMs 47.3, 52.7, and 56.7, had temperatures that were below the critical maximum lethal threshold of 75 ^{o}F that can lead to imminent salmonid stress and mortality. The maximum temperature recorded at the upper three reaches were a 72 ^{o}F surface reading at RM 47.3, and a "low" maximum temperature of 64 ^{o}F at a depth between 9-10 feet at the same site. The deeper thermograph at RM 14.5 was also below the 75 ^{o}F threshold at 73.5 ^{o}F.

The temperature differences between surface and subsurface waters are likely indicative of a combination of conditions that may include thermal stratification due to density differences between cooler, deeper water at the bottom of the specific pools, compared to warmer water at the pool's surface. Density driven thermal stratification may also be further influenced by a lack of turbulent mixing between surface and subsurface water. Mixing of surface and subsurface waters may also, in part, be reduced or eliminated by low river discharges, in concert with insufficient instream roughness and habitat structure (such as large woody debris, boulder placement, etc.), leading to subsurface stagnation.

Often in thermally stratified pools any deeper, and usually cooler bottom water layers that may be present will be utilized by salmonids and other cool water biota as thermal refugia from noticeably warmer surface temperatures. Exceptions do occur where cooler bottom waters undergo subsurface stagnation leading to anoxic pockets, such as conditions thought to occur in the Mattole estuary, and documented in the Russian River estuary, in which case salmonids will retreat to more favorable habitats (Goodwin, et al., 1993; MRC, 1995). Comparing the MWATs and the maximum temperatures at the paired thermograph locations to results available at this office from the MSG's 2001 Summer Steelhead Survey Report (MSG, 2001), however, are inconclusive when trying to ascertain if the cooler pool bottoms were utilized as thermal refugia. All of the MSG's dive surveys were conducted and reported for specific reaches that did not segregate individual habitat units from the stream reach being surveyed. Four of the six reaches (Reach 4 between RMs 51.3-52.8, Reach 6 between RMs 45-47.4, Reach 12 between RMs 12.6-14.9, and Reach 16 between RMs 0-1.3) with paired thermographs at different depths, all had salmonids present (MSG, 2001). However, salmonids were also present at six other locations without paired thermographs in place. Further investigations that include fish counts at specific habitat units would be helpful to ascertain if these deeper pools are being used as thermal refugia by salmonids in the Mattole River.

<u>Thermal Infrared Temperatures, Mattole River mainstem:</u> The following general discussion in the Estuary-Mainstem Subbasin regarding thermal infrared (TIR) temperature imaging is applicable to subsequent subbasins where such imaging and analysis were used to derive median surface water temperatures. TIR imaging was used to derive point-in-time, median surface water temperatures for the mainstem and select tributaries to the Mattole River on July 19 and 20, 2001. In contrast to instream thermographs that can be programmed to collect water temperatures at set time intervals (minutes to hours) and for lengthy periods of time (days to months), TIR image derived temperatures are usually collected at a moment in time, and during a single day or days. The Mattole River mainstem and select tributaries were flown by a helicopter equipped with an TIR sensor and a visible band color video camera that were situated side-by-side in a gyro-stabilized mount attached to the helicopter's underside. Data were gathered along longitudinal profiles of the Mattole River mainstem at an average height of 1800 feet, between the hours of 2:23-4:03 p.m. on July 19, 2001. Select tributaries were also flown but at an average elevation of 1400 feet on July 20 between 1:55-5:29 p.m. All flights and data collection were performed by Watershed Sciences under contract to the Regional Water Board (Watershed Sciences, 2002).

From the TIR surveys temperature data were formatted into Excel spreadsheets and associated charts. The TIR charts are of particular interest because they provide an instant overview of maximum-median temperature distributions for a particular watercourse's longitudinal profile. Figure 6 is the TIR longitudinal profile for the mainstem Mattole River from the estuary to the headwaters.

Readily apparent are the similarities between the median temperature curves for the TIR profile of Figure 6, and that of Figure 5, maximum seasonal temperatures derived from instream temperature thermographs. Both display similar temperature changes from much cooler, headwater-upper reach temperatures, gradually warming in mid-reach areas and, again, cooling as the estuary is approached.

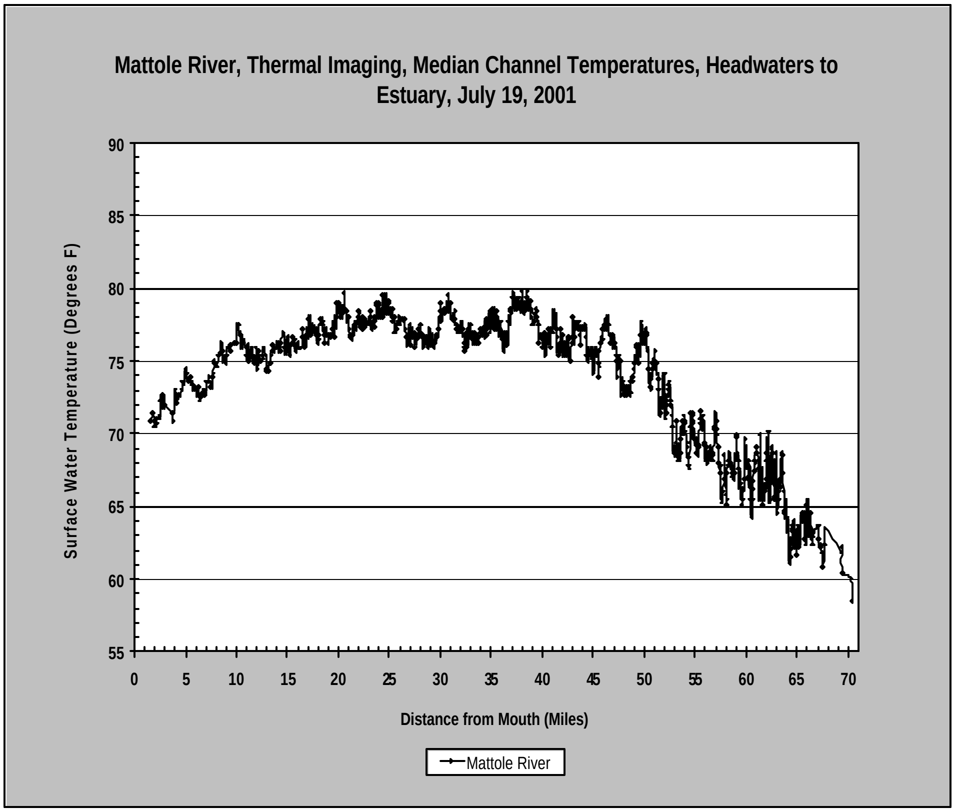

Figure 6. Median surface water temperatures, thermal infrared imaging, Mattole River, headwaters to the estuary, July 19, 2001.

Particularly interesting when reviewing the Mattole River TIR profile are the frequent dips in surface temperatures at certain stream miles. These localized drops in maximum temperatures are the influence of colder tributaries entering the warmer mainstem. For example, between RM 48 and 50, where both Bear and Blue Slide creeks enter the river, mainstem surface temperatures dropped approximately 6.7 ^{o}F. Other notable mainstem temperature dips occur at RM 36.7, where Westlund Creek lowers the mainstem temperature from 79.7 ^{o}F to 76.1 ^{o}F, and Honeydew Creek at RM 30.3, which locally lowered the mainstem temperature from 78.8 ^{o}F to 75.9 ^{o}F. During the TIR overflight, of fifteen tributaries detected entering the Mattole River, thirteen of them discharged cooler water into the mainstem, while only two, the NFK and UNFK Mattole rivers, contributed warmer surface waters to the mainstem. Table 4, below, is a summary of TIR median surface water temperatures and the differences between detected tributaries and the Mattole River mainstem during the July 19, 2001 overflight. In Table 4, RB and LB are the right bank and left bank, respectively, that the tributary enters the river in a downstream direction (Watershed Sciences, 2002).

Table 4. Thermal imaging, median surface water temperatures, Mattole River and select tributaries, July 19, 2001.

Tributary	River Mile	Tributary Surface Temperature (F)	Mattole River Surface Temperature (F)	SurfaceTemperature Difference (F)
NFK Mattole River (RB)	6.0	76.6	73.0	3.6
McGinnis Cr (RB)	9.8	75.0	76.3	-1.3
No Name (RB)	16.0	73.6	75.9	-2.3
Squaw Cr (LB)	17.2	70.0	76.8	-6.8
Unnamed Inlet (LB)	21.0	76.1	78.1	-2.0
Upper North Fork (RB)	29.3	78.8	76.1	2.7
Honeydew Cr (LB)	30.3	72.3	78.6	-6.3
Dry Cr (RB)	35.4	75.0	77.4	-2.3

Tributary	River Mile	Tributary Surface Temperature (F)	Mattole River Surface Temperature (F)	SurfaceTemperature Difference (F)
Westlund Cr (RB)	36.7	68.4	78.1	-9.7
Fourmile Cr (LB)	40.3	71.4	76.1	-4.7
Unnamed Trib (LB)	40.5	74.5	77.2	-2.7
Sholes Cr (LB)	42.5	63.7	76.6	-13.0
Grindstone Cr (RB)	44.9	71.4	75.9	-4.5
Blue Slide Cr (RB)	48.4	70.3	73.2	-2.9
Bear Cr (LB)	49.2	71.8	75.9	-4.1

As a rough comparison, temperatures from thermographs placed by the MSG and the Regional Water Board were extracted from their raw data files for July 19, 2001, the day of the overflight, and paired with a similar TIR temperature point that is within approximately 0.1 mile of the thermograph. Near ocean reaches of the estuary were not analysed as a persistent coastal fog layer prevented thermal imaging during the day of the overflight. Table 5 and Figure 7, below, are the results of the temperature pairings and, as can be seen, the fit is very close between the two data sets.

Due to set time intervals programmed into thermographs exact time matches between the two sets of temperature data are not possible. The comparison should also be further qualified in that the TIR results are, as mentioned, strictly surface derivations from the mid-channel that were calculated as median temperatures derived from maximum and minimum extremes recorded in the imaged data set. Also, thermographs in wider streams, such as at most of the paired locations in the Mattole River, are usually deployed and anchored below the water's surface and near the rivers edge, or at readily accessible pool-riffle tail outs in narrower channel reaches. Undetected cool water seeps, springs and hyporheic flow may further influence temperature disparities between TIR and thermograph temperatures.

Table 5. Mattole River mainstem, maximum and median temperatures from the headwaters to the mouth, thermal imaging vs. remote thermographs, July 19, 2001.

River Mile (TIR)*	River Mile (MSG)*	Hobo Maximum Temperature (F) 7/19/01	Hobo Time (p.m.)	TIR Median Temperature (F) 7/19/01	TIR Time (p.m.)	Major Upstream Watercourse
3.96	3.3	67.8	2:30	73.0	2:25	NFK Mattole River
4.36	3.5	75.8	2:11	72.6	2:26	NFK Mattole River
7.8	6.2	77.6	2:16	75.0	2:30	Conklin Cr
9.36	7.5	76.7	3:00	75.9	2:32	Conklin Cr
17.01	14.5	79.0	2:22	76.8	2:40	Squaw Creek (surface)
28.7	25.2	77.7	2:54	76.6	2:57	UNFK Mattole
49.2	42.9	74.5	3:32	75.6	3:26	Big Finley Cr
53.5	47.3	67.4	3:31	68.5	3:34	Big Finley Cr (surface)
60.4	52.7	60.2	3: 00	66.4	3:46	McKee Cr surface)
61.7	53.9	65.2	3: 59	65.7	3:48	Vanauken Cr
65	56.7	62.9	3: 56	63.7	3:55	Gibson Cr (surface)
69.4	59.4	60.1	3: 50	60.4	4:01	Dream Stream
70.4	60.2	58.9	4: 20	58.5	4:03	Headwaters

*See TIR vs. MSG River Miles, below, for explanation of apparent mileage disparities

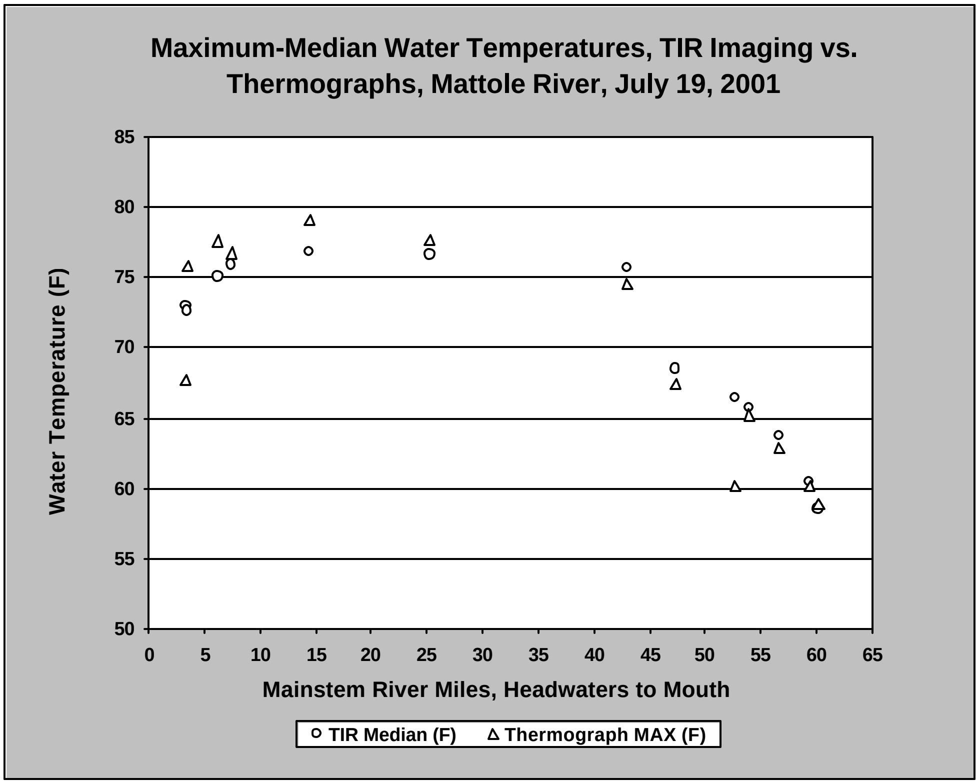

Figure 7. Mattole River mainstem maximum and median temperatures, thermal imaging vs. remote thermographs, Mattole River, headwaters to the mouth, July 19, 2001.

TIR vs. MSG river miles: A notable difference between the TIR derived data tables and other tables in this appendix are that the river miles do not correspond to one another. The TIR river miles from the estuary to the headwaters, and points in between, grow increasingly distant as a channel profile is completed when compared to river miles in data obtained from the MSG temperature files. The MSG relied on historic distances that were not calibrated using state of the art GIS capabilities. The TIR data is geo-referenced for those watercourses flown on July 19-20, 2001, and are presumed to more accurately reflect true river miles. Since nearly all of the data provided to this agency for the Mattole watershed, except that in the recent TIR report, relied on river mileages used in the past no attempt was made to interpolate between the two data sets. A correctional factor was attempted but there is not a consistent number that can be applied to equivalent points between the two mileage sets. As was done above in Table 5 and Figure 7, tributaries and readily discernable landmarks should instead be used to provide points of reference to establish equivalent river locations.

The advantage of the TIR data are that entire watercourses not obscured by fog, clouds or tree canopy, can be observed end-to-end as a visual temperature continuum. Unsuitably warm, or favorably cool surface water areas can be differentiated that may provoke salmonids to either flee from and/or seek thermal refugia, respectively. However, without the ability to scan below the surface escape refugia, such as deep pools that may be thermally stratified with cooler, deeper water, and heavily sheltered stream segments are not discernible.

Watershed Sciences provided a list, paraphrased below, for TIR data that regulatory agencies and interested parties, such as watershed organizations, can use to fine tune watershed and stream data gathering efforts and assessments (Watershed Sciences, 2001):

- Temperature patterns and profiles provide a spatial context for analysis of seasonal temperature data from in-stream thermographs and for future deployment and distribution of in-stream monitoring stations.
- The temperature profiles also provide information for basin wide, reach, and sub-reach areas, such as cool water tributaries, seeps, and subsurface flow distributions that may provide thermal refugia for salmonids. Instream and near-stream habitat information such as canopy cover, channel morphology, etc., provided by the color videos and TIR digitized images, can also be analysed as they are represented during the time of the survey and compared to future conditions and trends.
- Temperature profiles may be useful in calibrating reach and basin wide temperature models.
- Other data sets, such as maps and GIS layers, that may include factors that influence heating rates such as stream gradient and morphology, elevation and aspect, vegetation, and land-use impacts can be combined to ascertain spatial correlations that provide a more comprehensive understanding of how the stream is thermally structured.

Sediment:
V* was collected by the MSG during 2000 in the mainstem at RM 1.3 near Petrolia that had a calculated value of V* = 0.31, the highest of the eight locations for the sample year. This value is moderately high for residual pool filling and is above the mean V* = 0.21 adopted for the Garcia River TMDL as protective of the COLD beneficial use of water.

In addition to one site on the mainstem, D50 values were determined for eight other tributaries during 2001 by staff from the Regional Water Board. Two riffles in the mainstem site located upstream of the Dream Stream in the southern subbasin had a mean D50 = 34 mm. The minimum and maximum mean D50 for the two riffles sampled was 30 mm, and 38 mm, respectively. The overall mean D50 = 34 mm for this site is smaller by half than the mean D50 = 69 mm established for the Garcia River TMDL and would not be protective of the COLD beneficial use.

Northern Subbasin

The Northern Subbasin includes two major tributaries, the NFK and UNFK Mattole rivers. The headwater reaches of both these tributaries are primarily owned by the Pacific Lumber Company (PALCO). Information concerning water quality and stream temperatures made available to this agency by PALCO, were in summary form for 1991-1994. The data was extracted during the review of timber harvest plans and PALCO's Sustained Yield Plan (PALCO, 1996), submitted to the Department of Forestry and the Timber Harvest Unit of this office. PALCO also provided to the Regional Water Board raw and summary temperature files for select years from 1996 through 2001. Only years 2000 and 2001 temperature data were analysed, as 1996-1999 data represented temperatures from late July through September and October. This brief time period may not have captured representative high and low temperatures as would data collected over an entire summer. Very limited water temperature data in the downstream reaches of the NFK and UNFK Mattole rivers were collected by the MSG.

Water Chemistry and Quality:
As mentioned above, basic water chemistry and field metrics were collected under the SWAMP in the NFK Mattole River during summer, 2001. None of the analyses, which included phosphates and nitrates, indicated a waterbody that was overloaded with nutrients, metals, carbonates, or other measured chemical constituents.

Table 6 are basic field data collected by the Regional Water Board. The instantaneous grab sample on April 20, 2001, exceeded the numeric target for a pH = 8.5 in the Basin Plan for the Mattole River. Dissolved oxygen and specific conductance were within Basin Plan numeric targets. Even for pH caution must be used in interpreting single, point-in-time field grab samples; additional, and more temporally spaced sampling events would be needed to conclusively determine if there is a trend for any one sampling metric to exceed, or stay within Basin Plan and/or salmonid and other biotic thresholds.

Table 6. Dissolved Oxygen, pH, and specific conductance collected by the SWAMP, Regional Water Board, 2001.

Date	Dissolved Oxygen (mg/l)	pH (standard units)	Specific conductivity (micromhos)
4/20/2001	9.3	8.9	255
5/17/2001	8.9	8.3	281

Water Temperature:

There are no water temperature monitoring sites listed in current THPs or the PALCO-SYP for the NFK Mattole River and, as tabulated below, there are three tributaries located in the UNFK that were sampled during three different time periods. All samples were collected by the California Dept. of Fish and Game (DFG) using "Temperature Mentors." Temperature locations referenced for the Northern Subbasin are included as Figure 26, Map 1 at the end of this appendix.

Table 7. Annual average high temperature results from PALCO's SYP for tributaries to the UNFK Mattole River.

Tributary	Date	Annual Avg. High Temp (^{o}F)
Rattlesnake Creek	8/13/93	66.2
Rattlesnake Creek	7/25/94	69.0
Green Ridge Creek	9/23/93	66.0
Green Ridge Creek	8/1/94	70.5
Oil Creek	8/12/91	80.0
Oil Creek	8/12/93	77.0
Oil Creek	7/25/94	78.0

As Table 7 shows, and as contained in other reviewed documents such as timber harvest plans, only the annual high temperatures for specific reporting periods are given. There is no useful, long and/or short-term information to be gleaned from this summary information, and it should be used as informational only. For example, a single average reported high summer temperature at a single point downstream in a watercourse cannot be used to ascertain a stream's usefulness as suitable habitat for salmonids or other organisms. It can, however, be positively stated that in Oil Creek during 1991, 1993, and 1994, the average high temperatures exceeded the critical peak lethal temperature threshold of 75 ^{o}F established for salmonid survival. Reportable MWATS, as well as maximum summer temperatures, would have been much more useful for inclusion in this report, and also for greater utility in the limiting factor analysis being formulated by DFG.

The MSG and PALCO also furnished useable raw and summary temperature files from thermographs deployed from 1997 through 2001. Specific temperatures for available record years are represented in Tables 8 and 9 and Figures 8 and 9. respectively. The thermographs were located in NFK Mattole River approximately 9 miles upstream from the mainstem, Sulphur Creek, tributary to the NFK Mattole River, and the UNFK Mattole River approximately 2.0 and 4.5 miles upstream from the mainstem.

MWATs ranged from 64.4 ^{o}F during 2001at Sulphur Creek, to 71.1 ^{o}F at the UNFK Mattole River during 1998. The MWATs during all record years in the data set are not considered fully suitable of the needs of several cold water fish species, including coho salmon and steelhead trout, as they are above their preferred MWAT range of 50-60 ^{o}F.

Table 8. Maximum weekly average temperatures for the NFK Mattole River and the UNFK Mattole River, 1997-1999.

Tributary	River Mile*	MWAT (F) 1997	MWAT (F) 1998	MWAT (F) 1999	MWAT (F) 2000	MWAT (F) 2001
NFK Mattole River	4.7 + 0.5		69.7			
NFK Mattole River US	4.7 + 9.0				65	
Sulphur Cr	4.7 + 10.5				65.5	64.4
UNFK Mattole River	25 + 2.0	70.1	71.1	69.8		
UNFK Mattole US	25 + 4.5				69.4	67.8

*River mile indicates locations of the confluence of the tributary from the Mattole River mouth, the + indicates distance upstream the thermograph was located from the confluence of the tributary to the Mattole mainstem. Records were available in summary form from the MSG and complete data sets from PALCO.

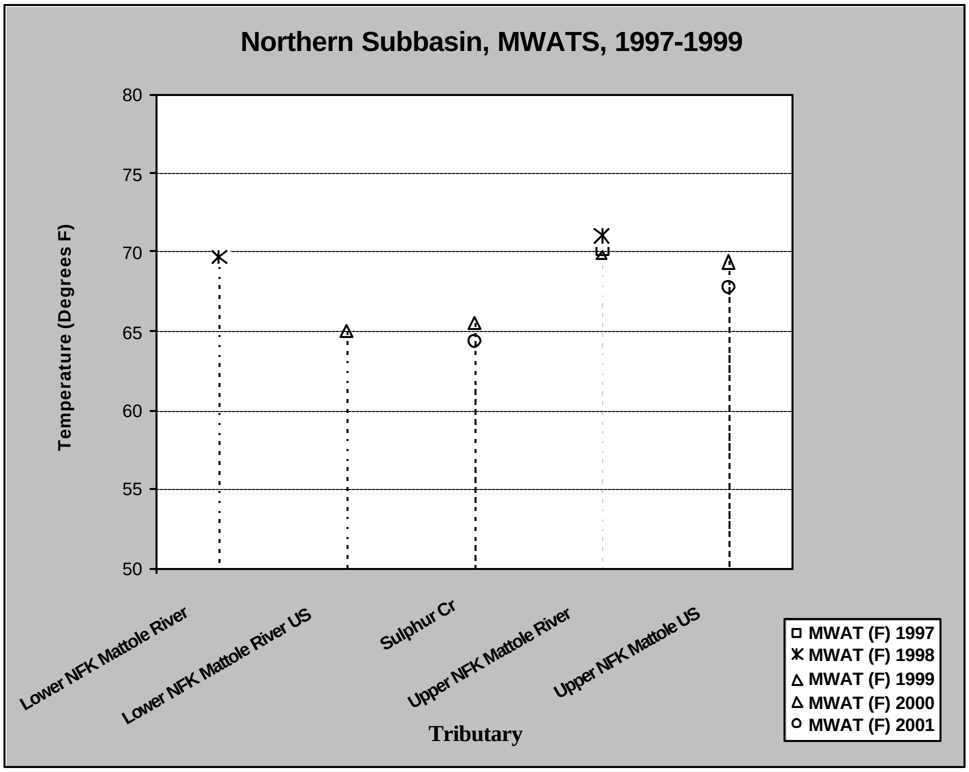

Figure 8. Maximum weekly average temperatures for the NFK and the UNFK Mattole rivers, 1997-1999.

In the Northern Subbasin in addition to Sulphur Creek and NFK and UNFK Mattole rivers, maximum summer temperatures, summarized in Table 9 and Figure 9, respectively, were also provided for one other tributary to the mainstem, Conklin Creek. Except for the 74 ^{o}F and 72 ^{o}F in the NFK and UNFK Mattole rivers in 1996, and a 74.6 ^{o}F nine miles upstream in the NFK Mattole River during 2000, all of the tributaries exceeded the critical peak lethal temperature threshold of 75 ^{o}F for salmonid survival. Sulphur Creek was marginally acceptable at 75 ^{o}F during 2001, but exceeded the peak threshold during 2000 when a 76 ^{o}F temperature was recorded. However, as cited above, Sulphur Creek exceeded acceptable MWATs for both years. For both metrics, two years of data are not sufficient to detect if there is a downward temperature trend for Sulphur Creek. Excluding the exceptions discussed above, these reaches are not supportive of the COLD beneficial use of water for salmonid habitat.

Table 9. Maximum summer temperatures for the NFK Mattole River, UNFK Mattole River and Conklin Creek, 1996-2001.

Tributary	River Mile*	MAX (F) 1996	MAX (F) 1997	MAX (F) 1998	MAX (F) 1999	MAX (F) 2000	MAX (F) 2001
NFK Mattole	4.7+0.5	74	81	81			
NFK Mattole US	4.7+9.0					74.6	
Sulphur Cr	4.7+10.5					76	75
Conklin Cr	7.9+0.5			78		79.9	
UNFK Mattole	25+2.0	72	82	82	80	80.8	
UNFK Mattole US	25+4.5					78.3	76.9

*River mile indicates locations of the confluence of the tributary from the Mattole River mouth, the + indicates distance upstream the thermograph is located from the confluence of the tributary to the Mattole mainstem.

Figure 9 graphically illustrates the temperature data in Table 9.

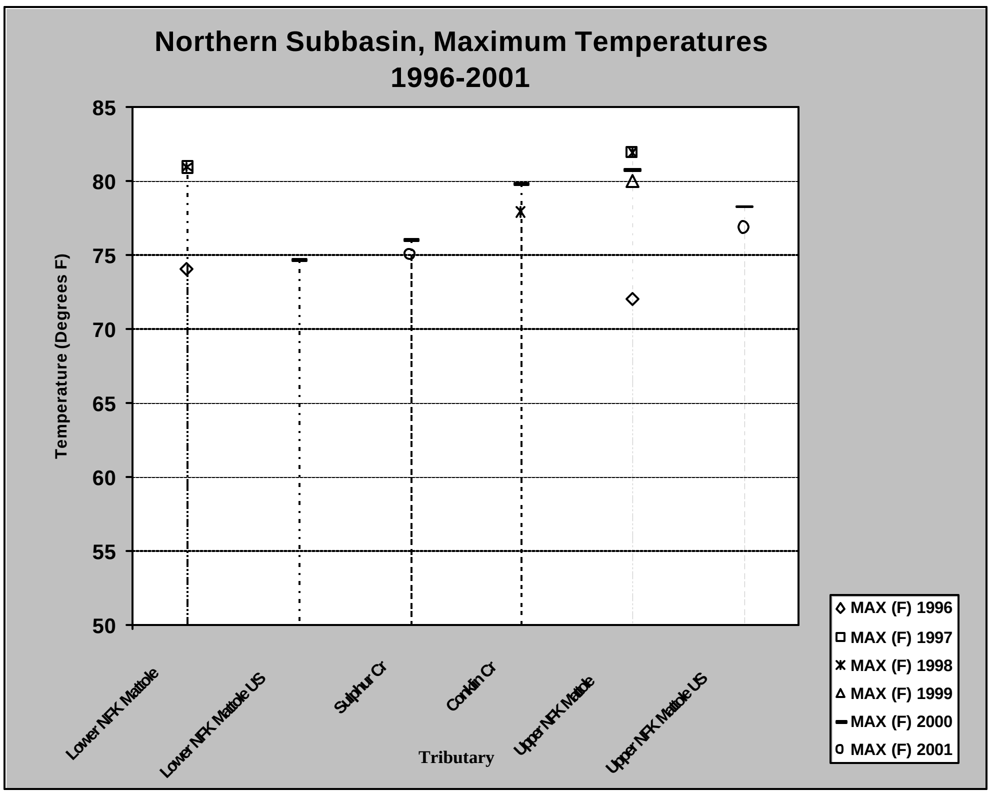

Figure 9. Maximum summer temperatures in the NFK and UNFK Mattole rivers, and ConklinCreek, 1996 to 2001.

The summer maximum temperatures in the above tributaries are within the same range as those recorded in the lower reaches of the mainstem Mattole River that were lethal to summer rearing chinook salmon in 1987. Department of Conservation, California Geological Survey’s (CGS) analysis indicates that both the NFK and UNFK Mattole rivers have some of the highest percentage of disturbed channel and streambank erosion of all of the five subbasins. Large areas of sediment deposition are also noted. With such continuous channel disturbances, riparian tree species providing a functioning shade canopy over the watercourses from solar radiation probably do not have a chance to become permanently established. These factors may, in part, explain the high MWATs and peak maximum summer temperatures recorded in the two tributaries. Specific fluvial geomorphic and riparian canopy information was not available for Conklin Creek, however, the high temperatures recorded there may also be reflective of similar watershed conditions as those in the NFK and UNFK Mattole rivers.

Thermal Infrared Temperatures, NFK and UNFK Mattole rivers,: In the Northern Subbasin on July 20, 2001, TIR temperature imaging surveys were used to derive point-in-time, median surface water temperatures for the NFK Mattole River and a single tributary, the East Branch NFK. Also surveyed were the UNFK Mattole River and two of its larger tributaries, Rattlesnake Creek and Oil Creek.

NFK Mattole River: Figure 10 represents median surface water temperatures from TIR data for the NFK Mattole River. Headwater reaches between RMs 12.3 and 9.6 were especially variable, and were acknowledged to have questionable accuracy due to the watercourses small size and extensive riparian cover that made surface water imaging difficult. However, from RM 9.6 downstream, accurate imaging was achieved (Watershed Sciences, 2002). As seen in Figure 10, there is a large, upward spike in surface temperatures from approximately RM 6.8 to 5.8. This coincides with the confluence of the East Branch NFK Mattole River that was considerably warmer than the mainstem NFK. An undetectable source of cool water was encountered between RM 5 and RM 4 that cooled the NFK below 70 ^{o}F. In general, the steady increase in surface temperatures from RM 5 to the mainstem Mattole River coincides with an open alluvial floodplain and a paucity of riparian cover, both visible on the TIR video images. CGS's NCWAP fluvial geomorphic analysis also detected an open, alluvial channel morphology at this reach. For this reach of the NFK Mattole the open channel configuration, combined with a poorly shaded riparian corridor, allows increased inputs of solar energy that, in part, contibute to the elevated surface water temperatures.

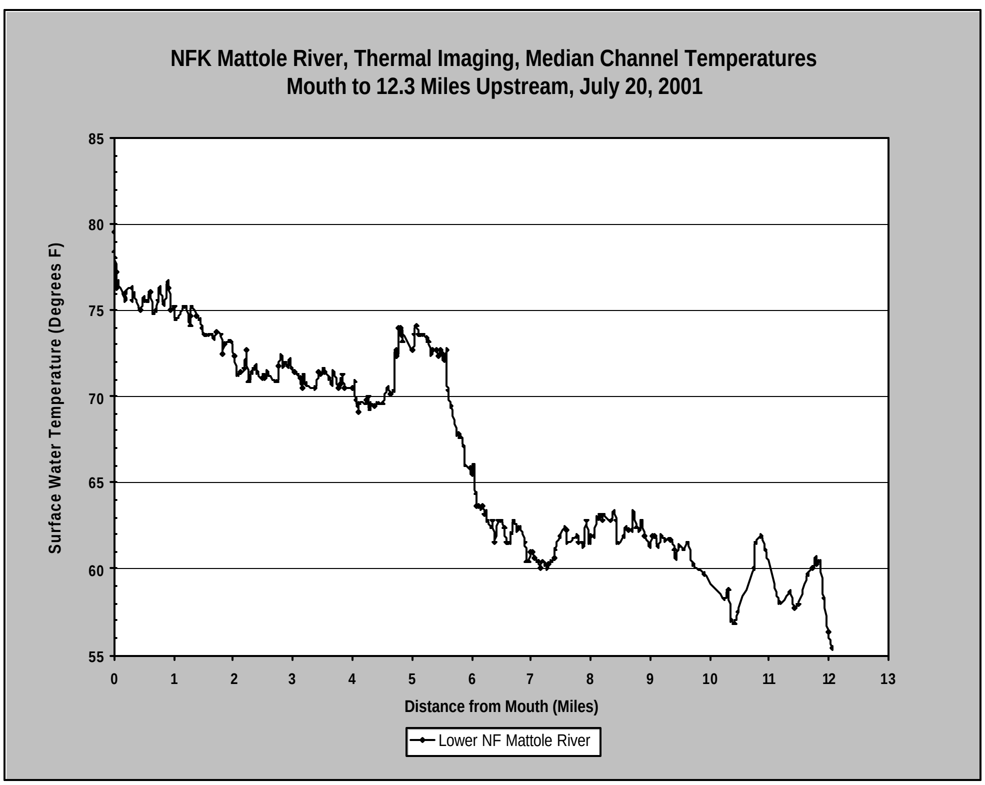

Figure 10. Median surface water temperatures, thermal infrared imaging, NFK Mattole River, July 20, 2001.

East Branch NFK Mattole River: The East Branch NFK Mattole River was surveyed from its confluence with the NFK Mattole River upstream for 6.4 miles. Travelling downstream it is readily apparent in Figure 11 that a steady warming trend takes place from the upper reaches of the East Branch NFK to its confluence with the NFK Mattole. The increasing temperature trend is occasionally interrupted by noticeably cooler water inputs, for example, near RMs 3.3 and 2.7 that caused localized depressions in the warmer surface waters of the East Branch NFK. On the survey day, the median surface temperatures were generally below the lethal threshold of 75 ^{o}F that is considered suitable for salmonids. It is again emphasized that the TIR calculated temperatures are applicable for the survey date only, and are not indicative of seasonal extremes.

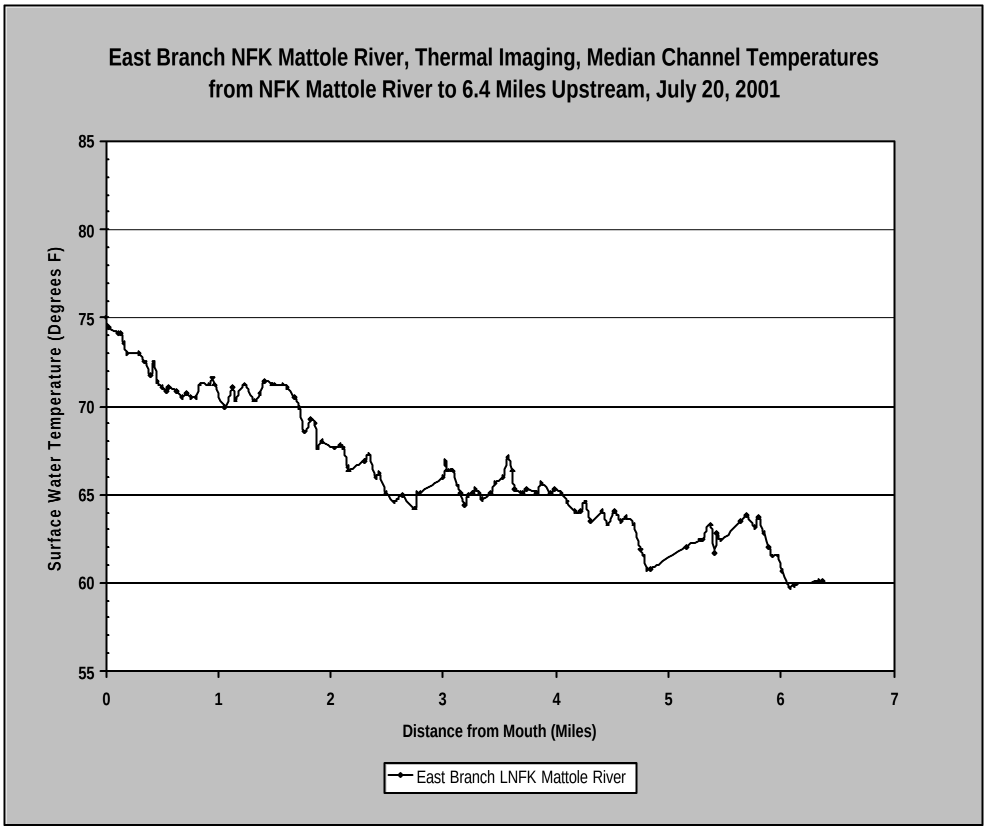

Figure 11. Median surface water temperatures, thermal infrared imaging, East Branch NFK Mattole River, July 20, 2001.

UNFK Mattole River, Rattlesnake, and Oil creeks: The UNFK Mattole River was surveyed July 20, 2001, to the confluence of Rattlesnake Creek, a distance of approximately 5.3 miles. The flight continued up Rattlensake Creek until surface water was no longer visible at which time the flyover diverted up Fox Camp Creek, ending the survey near RM 8.4. Oil Creek was also surveyed until surface water was undetectable at approximately RM 8. The survey then continued up Devils Creek for an additional 1.8 miles. Figure 12 graphically represents the distances flown and the median surface water temperatures collected during the survey. Considerable variance is apparent in the median surface water temperatures of all three surveyed watercourses, especially Oil Creek, that were attributed to very low flow conditions coupled with a narrow channel, making digital interpretation of the data difficult (Watershed Sciences, 2002).

The UNFK Mattole River, like the NFK Mattole River, contributed surface water that was warmer than that of the mainstem. Approximately 0.5 mile upstream from the mainstem, the UNFK Mattole River reached a peak median surface water temperature above 79 ^{o}F, then cooled slightly before entering the mainstem at 77.2 ^{o}F. Upstream from RM 0.5, median surface water temperatures continued to decline, reaching approximately 71 ^{o}F between RMs 2.7 and 3.0, then rising above 75 ^{o}F just downstream from the confluence of Oil Creek. The UNFK Mattole reached a minimum imaged median temperature just over 66 ^{o}F at the confluence of Rattlesnake Creek, coinciding with the end of visible surface water flow in the UNFK Mattole River.

Although there is very little continuous thermograph data available for the UNFK Mattole (see Table 9 and associated Figure 9), in general, similar maximum temperatures of 78.3 ^{o}F and 76.9 ^{o}F during 2000 and 2001, respectively, are comparable to a 75.2 ^{o}F median surface water temperature derived from the TIR data analysed at RM 4.5. At RM 2, maximum summertime thermograph temperatures were available from 1996-2000, but only a 72.0 ^{o}F thermograph maximum temperature during the 1996 sample year was comparable to an approximate 73.0 ^{o}F TIR median surface water temperature at the same location. All other thermograph locations at RM 2.0 from 1997-2000 were above 80 ^{o}F. Again, caution is urged in comparing the TIR, single day overflight median surface water temperatures to the maximum temperatures of thermographs deployed for an entire season, and usually at some depth below the water's surface.

Oil and Rattlesnake creeks, like all other watercourses surveyed during the TIR imaging flyover, also showed declines in median surface water temperatures from downstream reaches proceeding upstream. Oil Creek entered the UNFK Mattole at 77.2 ^{o}F and varied widely in an upstream direction before reaching 61.7 ^{o}F at the end of the survey.

Rattlesnake Creek provided most of the surface water flow to the UNFK Mattole River (Watershed Sciences, 2002), reaching a median surface temperature of 70.7 ^{o}F shortly before entering the UNFK. Median surface temperatures dropped sharply upstream from RM 6.75, reaching a minimum 54.1 ^{o}F in Fox Camp Creek, the end of the survey. As mentioned above, surface flows to Rattlesnake Creek appeared to end at RM 6.75 but the flight continued to the upstream visible extent of Fox Camp Creek near RM 8.4.

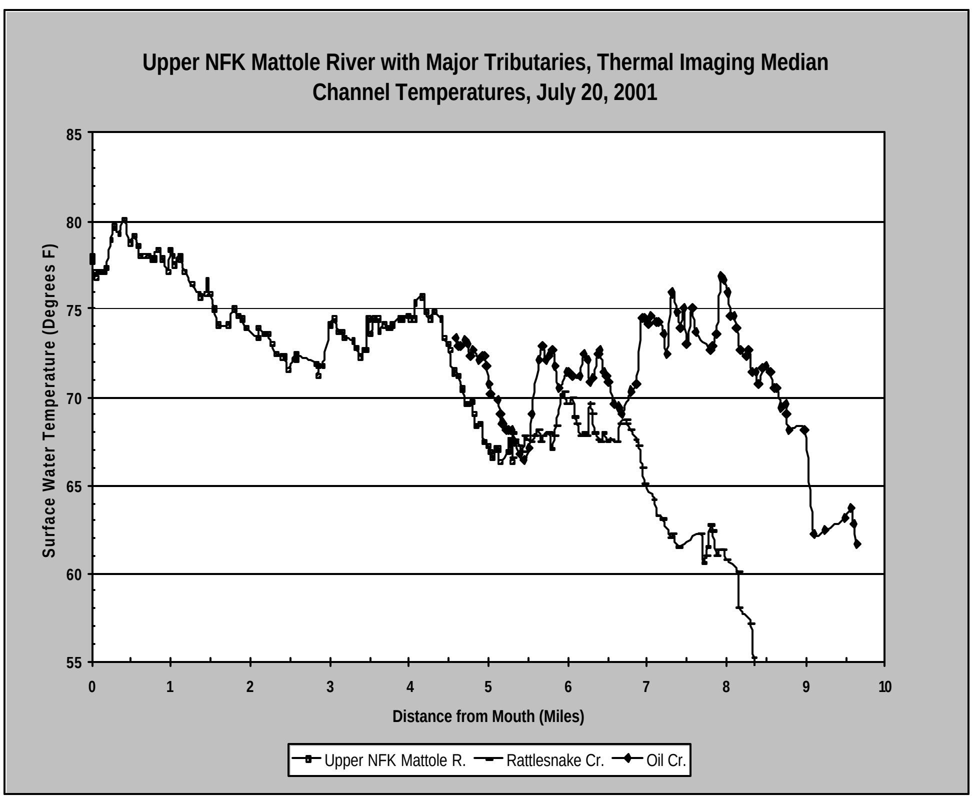

Figure 12. Median surface water temperatures, thermal infrared imaging, UNFK Mattole River, Rattlesnake and Oil creeks. July 20, 2001.

DFG Summer Temperatures: During 2001in the Northern Subbasin the DFG collected water temperatures in the four tributaries listed in Table 10, and graphically represented by Figure 13. Water temperatures were recorded during a two month period only from approximately mid-August and early September through mid-to late October.

All of the MWATs and maximum temperatures were recorded within the first or second week of the sampling period. East Mill Creek had an earlier MWAT date because the thermograph was placed during the latter part of August, while Conklin, NFK Mattole, and Boots creeks, tributary to Conklin Creek, were placed the first week of September. All of these temperatures would indicate that seasonally higher temperatures were probably recorded earlier in the year, most likely in July or early August. A review of thermograph results for a generally accepted recording season, usually May through mid- October, show that temperatures peaked in mid- to late July or very early August and begin trending downward after mid- August (Regional Water Board, 2001). Because of the short recording periods the DFG temperature data is presented as informational only, as it is not comparable to data collected over an entire summer period. However, except for the 59.8 ^{o}F in Conklin Creek and 59.3 ^{o}F in Boots Creek, even for this abbreviated period of time, MWATs were not fully suitable of the needs of several cold water fish species, including coho salmon and steelhead trout, as all were above their preferred MWAT range of 50-60 ^{o}F. Without temperature results for July and early August it cannot be determined, but it appears likely, that both Conklin and Boots creeks may also have exceeded the preferred MWAT range for the various salmonid species during that time period.

Table 10. Northern Subbasin MWATS and maximum temperatures recorded by DFG, mid-August through mid-September, 2001.

Location	Hobo Placement	MWAT (F) 2001	MAX T (F) 2001	MWAT Date
Conklin Creek	~5500 ft upstream from Mattole River	59.8	67.4	9/11/2001
NFK Mattole River	~3.1 miles upstream from Mattole River	63.6	69.9	9/12/2001
East Mill Creek	~1000 ft upstream from Mattole River	60.9	63.4	8/30/2001
Boots Creek (Conklin Trib.)	~30 ft upstream from Conklin Cr.	59.3	64.6	9/11/2001

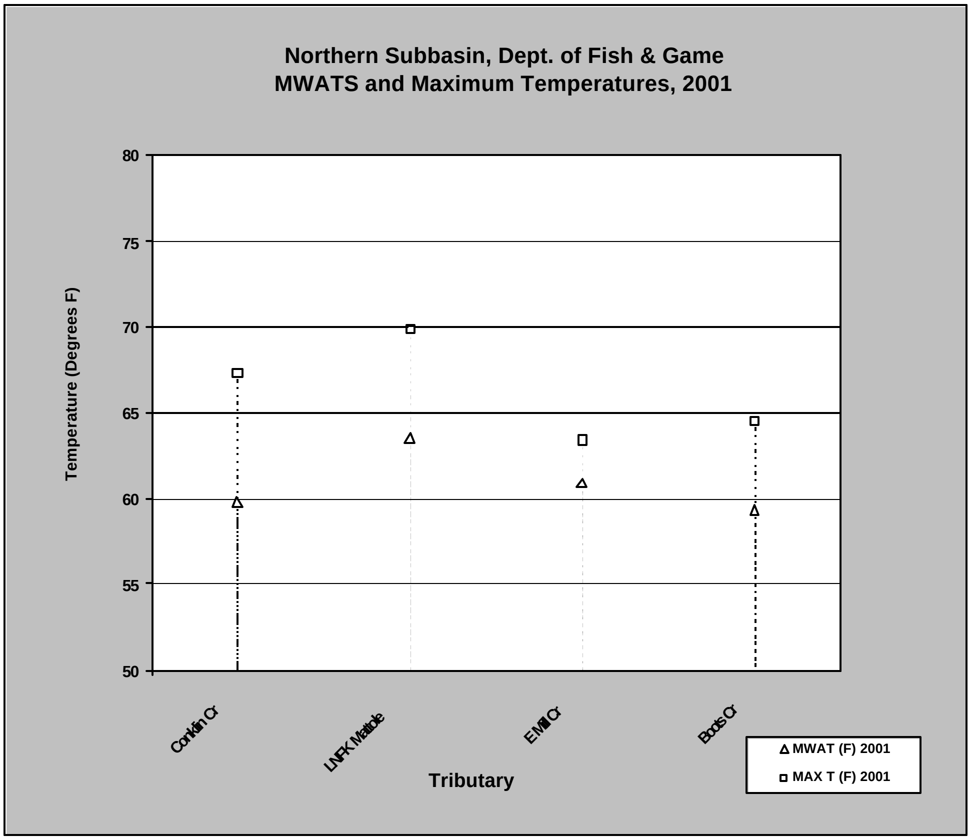

Figure 13. Department of Fish and Game, MWATs and maximum summer temperatures for select tributaries in the Northern Subbasin, mid-August through mid-October, 2001.

Sediment:

In the Northern Subbasin under a cooperative agreement with the BLM and the DFG, the MSG collected V* sediment data in Conklin Creek during 2000, and calculated a cumulative V* = 0.27. This value would indicate a low to moderate supply of sediment from upslope-upstream sources, however, it exceeds the Garcia River TMDL mean V* = 0.21 and would not be protective of the COLD beneficial use if this target were applicable to Conklin Creek.

Eastern Subbasin:

Water Chemistry and Quality:

On April 7, 2000, the Regional Water Board received notification of a diesel spill leaching from the Lester Bell property to Blue Slide Creek. The site is under waste discharge requirements issued by the Regional Water Board as WDR Order No. R1-2001-9, and also NPDES Permit No. CAG911001 (Regional Water Board, 2000). It was estimated that approximately 2000 gallons of diesel fuel may have been released from uncontained fuel storage tanks. The fuel release infiltrated the soil surface to deeper bedrock where it then migrated slowly toward Blue Slide Creek. Free product was visible as an oily sheen in Blue Slide Creek, and also discharging to the soil surface from a spring above the creek. The discharge point in Blue Slide Creek is approximately 1.6 miles upstream from its confluence with the Mattole River near Ettersburg.

SHN Consulting Engineers & Geologist, Inc. installed a remediation system consisting of a combination of containment-extraction trenches and associated pumps and piping that convey contaminated water to carbon-drum filters for treatment. Filtered groundwater is discharged to approved locations under the guidelines of the Waste Discharge Requirements and NPDES permit issued by the Regional Water Board. Recovered petroleum products are stored in drums for later transport to a licensed disposal facility. As of October 15, 2001, petroleum constituents were not detected in treated groundwater before being discharged to approved locations in accordance with the required permits. The site is being actively monitored by SHN and the Regional Water Board until all discharges of petroleum products are no longer a threat to the beneficial uses of water.

Additional water physical-chemical and/or quality records were not found during DWR, STORET, or Regional Water Board database searches for this subbasin.

Water Temperature:
Temperature records were available for Dry, Middle, Westlund, Mattole Canyon, Blue Slide, and Eubanks creeks in this subbasin. Mattole Canyon and Blue Slide creeks are the two largest tributaries designated as blue line streams on USGS topographic sheets. As Tables 11, and associated Figure 14 demonstrate, all MWATs for these tributaries were above the 50-60 ^{o}F range for optimal coho growth, except Eubanks Creek at 59.7 ^{o}F during 2001. Juvenile coho salmon were not detected in any of the four tributaries during Welsh's study (Welsh, et al., 2001). With MWATs consistently as high as those recorded from 1996 through 2001, coho salmon would not be expected near the locations of the thermographs. Temperature data were not available for the extreme upstream reaches and tributaries of the four subwatersheds. Viable salmonid populations may be present, similar to those detected in the headwater reaches of Bear Creek and Honeydew Creek, addressed later in the Western Subbasin. Temperature locations referenced for the Eastern Subbasin are included as Figure 27, Map 2 at the end of this appendix.

Table 11. Maximum weekly average temperatures from 1996 through 2001 for various tributaries to the Mattole River in the Eastern Subbasin.

Tributary	River Mile*	MWAT (F) 1996	MWAT (F) 1997	MWAT (F) 1998	MWAT (F) 1999	MWAT (F) 2001
Dry Cr	30.4 +0.1					65.5
Middle Cr	31.3 +0.2					61.5
Westlund Cr	31.7+0.1			67.9	63.1	62.5
Mattole Cyn Cr	41.1+0.1			73.3	71.3	70.8
Upper Mattole Cyn Cr (surface)	41.1 +3.1					70.7
Upper Mattole Cyn Cr (8 ft deep)	41.1 +3.1					65.2
Blue Slide Cr	42.0+0.1		69.1	70.8	68.2	
Eubanks Cr	47.7+0.1				61.1	59.7

*River mile indicates locations of the confluence of the tributary from the Mattole River mouth, the + indicates distance upstream the thermograph is located from the confluence of the tributary to the Mattole mainstem.

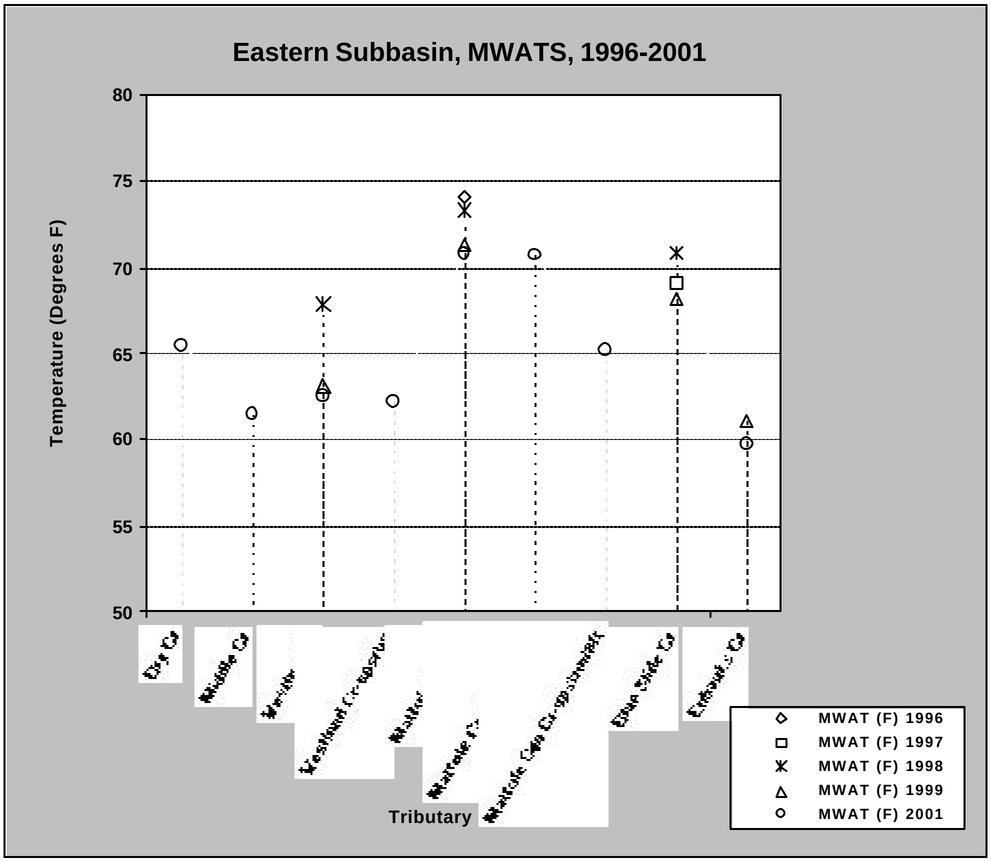

Figure 14. MWATs for Dry, Middle, Westlund, Mattole Canyon, and Eubanks creeks in the Eastern Subbasin, 1996 to 2001.

Maximum summer temperatures were extremely elevated in Mattole Canyon Creek during all years, but especially so in 1996, when a high of 88 ^{o}F was recorded. Dry and Grindstone creeks in 2000, and Blue Slide Creek in 1997 and 1998, exceeded the critical peak lethal temperature threshold of 75 ^{o}F established for the Garcia River TMDL for salmonid survival and are not supportive of the COLD beneficial use of water. However, Eubanks Creek during all sampled years, and Dry, Middle, Westlund, and Blue Slide creeks during 2001, were below the critical peak lethal temperature threshold of 75 ^{o}F established for salmonid survival.

Table 12. Maximum summer temperatures for various tributaries in the Eastern Subbasin from 1996-2001.

Tributary	River Mile*	MAX (F) 1996	MAX (F) 1997	MAX (F) 1998	MAX (F) 1999	MAX (F) 2000	MAX (F) 2001
Dry Cr	30.4+0.1					88	73.3
Middle Cr	31.3+0.2					64.4	68.3
Westlund Cr	37.1+0.1				67	69.5	68.4
Westlund Cr (upstrm)	31.7+1.0					66.9	
Grindstone Cr	39.0+0.1					78.1	
Mattole Cyn Cr	41.1+0.1	88		80	84		84.1
Mattole Cyn Cr-upstrm	41.1+3.1						81.6
Mattole Cyn Cr-upstrm (8ft)	41.1+3.1						68.4
Blue Slide Cr	42.0+0.1		79	78		74.4	
Eubanks Cr	47.7+0.1	70		68	67	67.8	68.1

*River mile indicates locations of the confluence of the tributary from the Mattole River mouth, the + indicates distance upstream the thermograph is located from the confluence of the tributary to the Mattole mainstem.

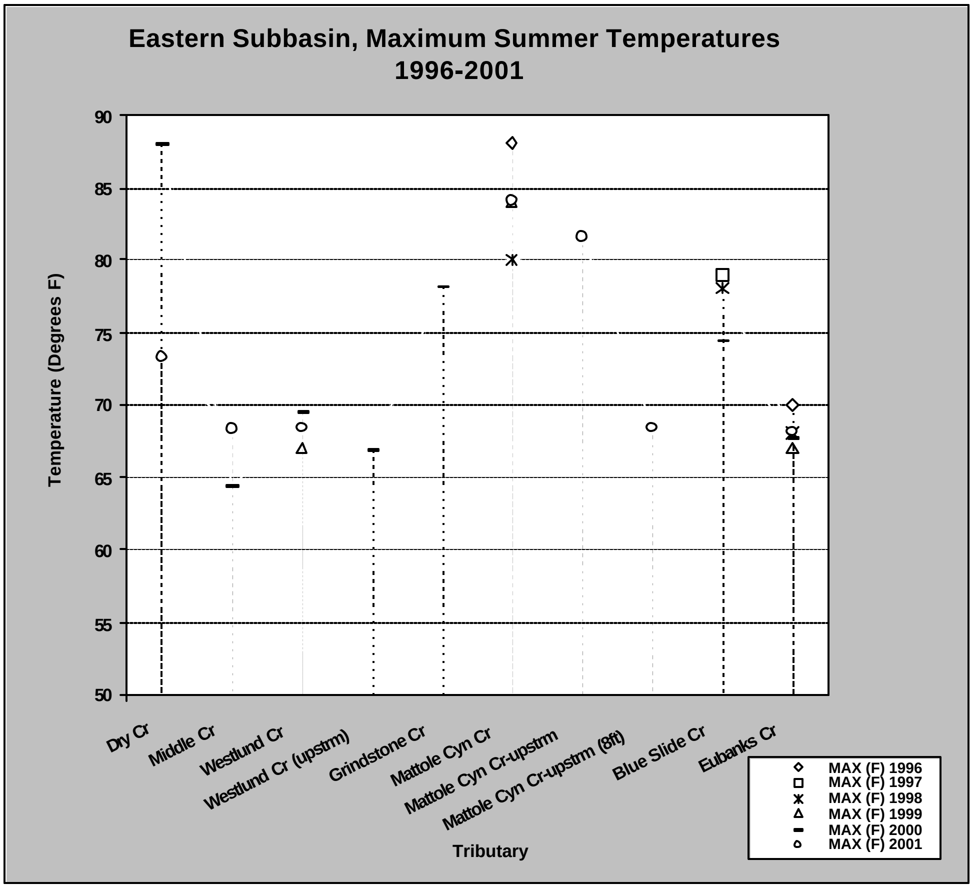

Figure 15. Maximum summer temperatures in ten tributaries to the Mattole River in the Eastem Subbasin, 1996-2001.

Mattole Canyon Creek, Thermal Infrared Temperatures: On July 20, 2001, TIR imaging surveys were used to derive point-in-time median surface water temperatures for Mattole Canyon Creek from its mouth to approximately RM 5.5, the point at which there was no visible surface flow (Figure 16). There is a high degree of variability for the median surface temperatures, as shown in Figure 16 where, at some locations, TIR imaging could not be obtained due to an extremely narrow channel, short areas of overhanging riparian vegetation, and subsurface stream flows. The abrupt end to the temperature trace in Figure 16 prior to Mattole Canyon Creek reaching the mainstem near RM 0.5 graphically represents a short reach where the watercourse flows subsurface. At this location the median surface water temperature reached approximately 81.1 ^{o}F, only 3 ^{o}F less than the seasonal maximum temperature of 84.1 ^{o}F collected by the Regional Water Board from a thermograph placed near the mouth during the summer of 2001. An upstream thermograph placed just below the water's surface by the MSG during 2001 recorded an 70.7 ^{o}F seasonal maximum temperature. The TIR median temperature at approximately the same location on July 20, 2001 was near 75.2 ^{o}F, a difference of only 4.5 ^{o}F. Both the TIR and thermograph temperatures follow a pattern similar to other subbasin tributaries, mentioned previously, of increasing dramatically when an open alluvial floodplain is encountered.

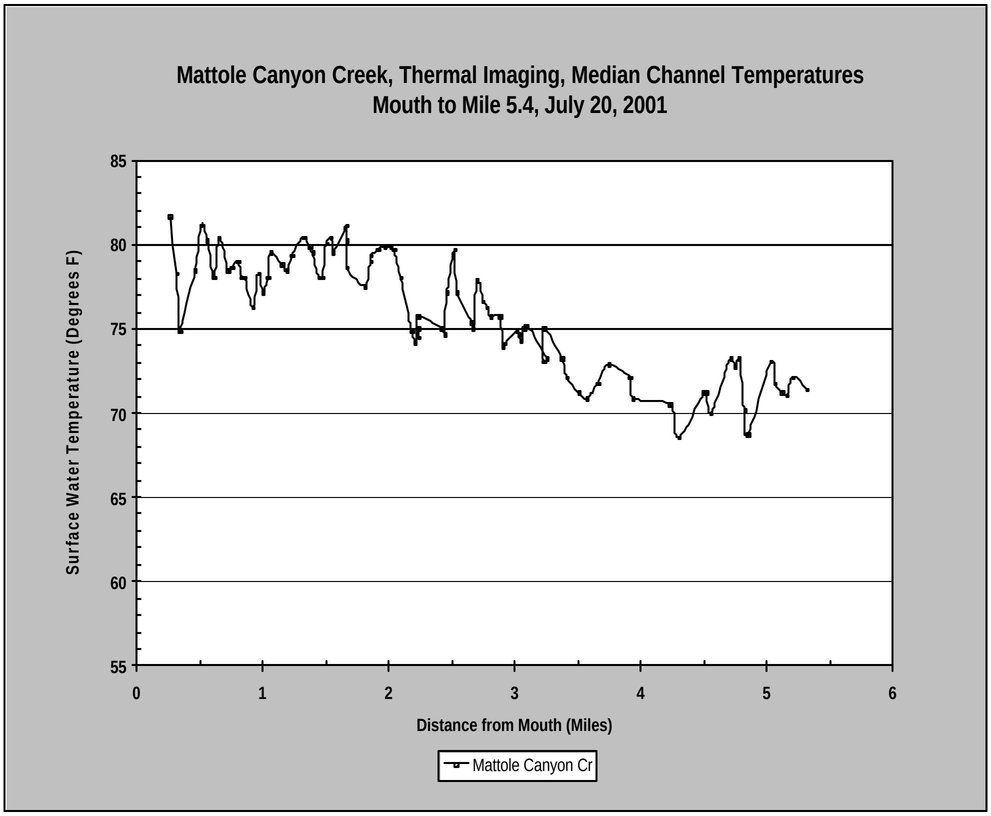

Figure 16. Median surface water temperatures, thermal infrared imaging, Mattole Canyon Creek, July 20, 2001.

<u>DFG Summer Temperatures:</u> During 2001in the Eastern Subbasin the DFG collected water temperatures in the five tributaries listed in Table 13, and graphically represented by Figure 17. Water temperatures were recorded during a two month period only from approximately mid-August through mid-to late October.

All of the MWATs and maximum temperatures were recorded within the first or second week of the sampling period. All of these temperatures would indicate that seasonally higher temperatures were probably recorded earlier in the year, most likely in July or early August. A review of thermograph results for a generally accepted recording season, usually May through mid- October, show that temperatures peaked in mid- to late July or very early August and begin trending downward after mid-August (MSG, 2001; Regional Water Board, 2001). Because of the short recording periods the DFG temperature data is presented as informational only, as it is not comparable to data collected over an entire summer period. Except for the 58.8 ^{o}F, 59.9 ^{o}F, 59.6 ^{o}F, and 58.5 ^{o}F in Sholes, upper Gilham, NFK Gilham, and mainstem Gindstone creeks, respectively, even for this abbreviated period of time, MWATs were not fully suitable of the needs of several cold water fish species, including coho salmon and steelhead trout, as all were above their preferred MWAT range of 50-60 ^{o}F. Without temperature results for July and early August it cannot be determined, but it appears likely, that lower Grindstone Creek may also have exceeded the preferred MWAT range for the various salmonid species during that time period.

Table 13. Department of Fish and Game, MWAT and maximum summer temperatures, select tributaries in the Eastern Subbasin, mid-August through mid-October.

Location	Hobo Placement	MWAT (F) 2001	MAX (F) 2001
Fourmile Cr, SFK	~4240 feet upstream from Mattole River	61.5	66.2
Fourmile Cr, WFK	~850 feet upstream of confluence with Fourmile Creek	61.5	69.2
Fourmile Cr, main	~400 feet upstream from Mattole River	64.2	73
Gilham Cr, mouth	~200 ft upstream from Mattole River	60.7	63.4
Gilham Cr, upper	~6850 ft upstream from Mattole River	59.9	62
Gilham Cr, NFK	~50 ft upstream from Gilham Cr	59.6	62
Grindstone Cr, lower	~225 ft upstream from Mattole River	62.8	70.9
Grindstone Cr, main	~2.5 miles upstream from Mattole River	58.5	61.3
Sholes Cr	~1000 feet upstream from Mattole River	58.8	61.9

Interestingly, during the short sample period all of the maximum water tempertatures were below the 75 ^{o}F peak lethal threshold necessary for survival established for many West Coast salmonids.

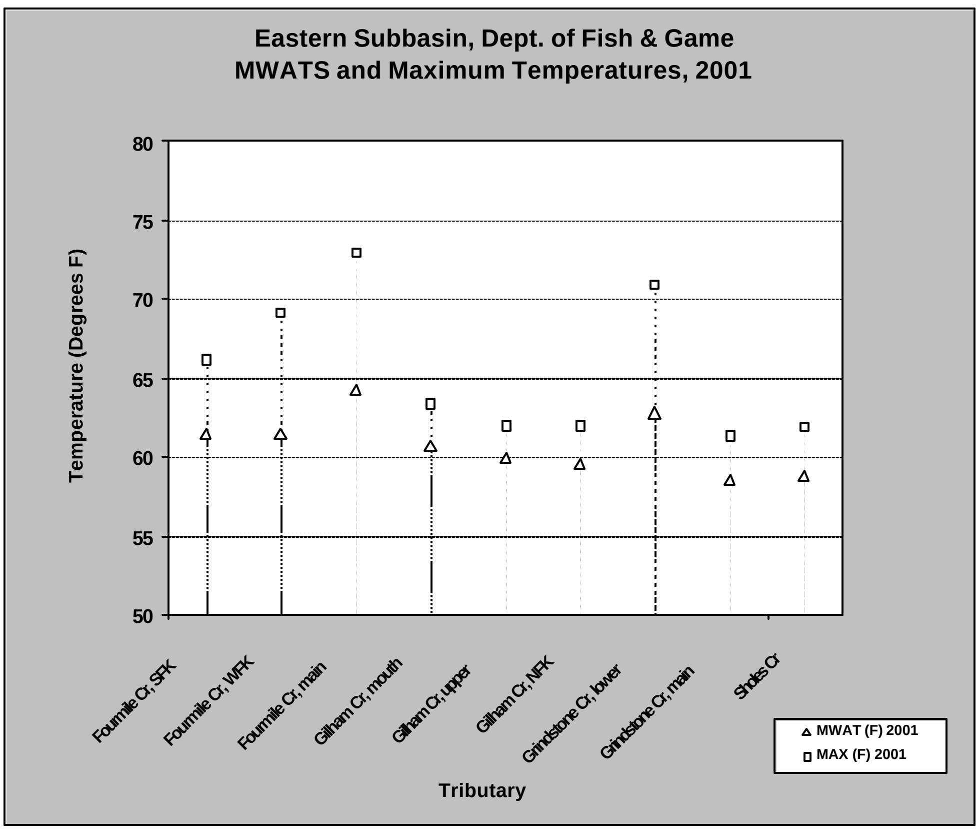

Figure 17. Department of Fish and Game, MWATs and maximum summer temperatures, select tributaries in the Eastern Subbasin, mid-August through mid-October, 2001.

<u>Sediment:</u>
V*: During 2000 in the Eastern Subbasin the MSG collected and calculated V* in Westlund and Middle creeks. Both streams had identical values for mean V* = 0.25, indicating low rates of residual pool filling, but still slightly above the recommended mean V* < 0.21, established for the Garcia River.

Southern Subbasin

Water Chemistry and Quality:
On October 29, 2002, the Regional Water Board with assistance from the DFG and the MSG, collected basic field physical parameters that included dissolved oxygen, specific conductance, pH, temperature, and turbidity in the Southern Subbasin. Sampling was prompted by concerned citizen's observations that salmonids were being stranded in disconnected pools between reaches of the river that were completely dry. Except for remnant pools between bedrock formations, gravel bars, and riffles, field observations confirmed that the Mattole River upstream from the confluence of McKee Creek was largely dewatered. Table 14 summarizes results of the data gathering conducted along the Mattole mainstem on October 29, 2002. Sampling took place in isolated pools from McKee Creek at the "Junction Pool" to a headwater reach just downstream from Ancestor Creek.

Table 14. Regional Water Board, water quality physical sampling, various locations in the Mattole mainstem, Southern Subbasin, October 29, 2001.

Mattole Mainstem Sample Station and Depth*	Salmonids Present (Yes/No)	Temperature (Deg F)	Dissolved Oxygen (mg/l)	Specific Conductance (Micromhos)	pH (Standard Units)	Turbidity (NTU)
Junction Pool/McKee Cr.						
Pool #1-1.5 ft	Yes	51.4	4.61	102	7.3	2.1
Stanley Cr.						
Pool #2-1.0 ft	Yes	46.9	4.52	89	7.77	0.9
4.2 ft	Yes	46.4	4.37	89	7.45	1.1
4.7 ft	Yes	46.4	4.37	89	7.45	1.1
Pool #3-0.5 ft	Yes	45.1	6.8	102	7.6	1.6
Pool #4-0.6 ft	Yes	45.2	8.35	111	7.53	
Lost River Cr.						
Pool #5-0.5 ft	No (Sticklebacks +)	45.0	0.2	137	6.9	8.2
Pool #6-4-6 ft	No (Sticklebacks +)	44.5	1.5	131	7	6.7
Dream Stream						
Pool #7-0.5 ft	Yes	48.0	1.78	89	7.24	0.8
Pool #8-0.5 ft	Yes	44.5	4.61	102	7.3	2.1
Ancestor Cr.						
Pool #9-1.0 ft	Yes	48.4	3.9	77	7.24	6.7

*Depth = the depth under the water surface the multiparameter probe sensor was placed; only one depth at a locations was the approximate midpoint to the pool bottom (pool was to shallow to sample at varying depths).

All physical parameters, except dissolved oxygen, represented in Figure 18, were not considered stressfull to salmonids during the day of the survey. It appeared that those salmonids present were probably steelhead, which are usually able to withstand more extreme conditions than most other salmonids. With the exceptions of Pool 4 and Pool 5, where salmmonids were not detected, dissolved oxygen concentrations were low enough to be considered stressful for those salmonids present in the remaining pools. For example, moderate production impairment to salmonid rearing usually occurs near 5 mg/l of dissolved oxygen (SWRCB, 2002). Coho salmon have been known to withstand 95-100% survival in test water where dissolved oxygen levels ranged from 2.1 mg/l down to 1.3 mg/l. In other situations, coho salmon experienced complete survival where dissolved oxygen levels were as low as 3mg/l to 3.3 mg/l (Hicks, 2000). It should be noted that the preceeding figures quoted were from laboratory experiments, conducted in water temperatures between 64-68 ^{o}F, when metabolic rates for the test organisms were probably very high. As depicted in Table 14, the salmonids observed on October 29 were existing in much lower water temperatures, probably depressing their metabolic rates enough to enable them to withstand the lowered dissolved oxygen levels. It should be noted, that the Regional Water Board sampling was done at specific points and fixed depths in the pools tested, hence, physical conditions and any variances within the volume of entire pools were not fully characterized. Even at locations where the instrument readings of dissolved oxygen were very low, those salmonids observed were likely able to take advantage of pockets of more oxygenated water, such as between the air-water interface, or at small seepages of water into the pool that point sampling for dissolved oxygen could not detect.

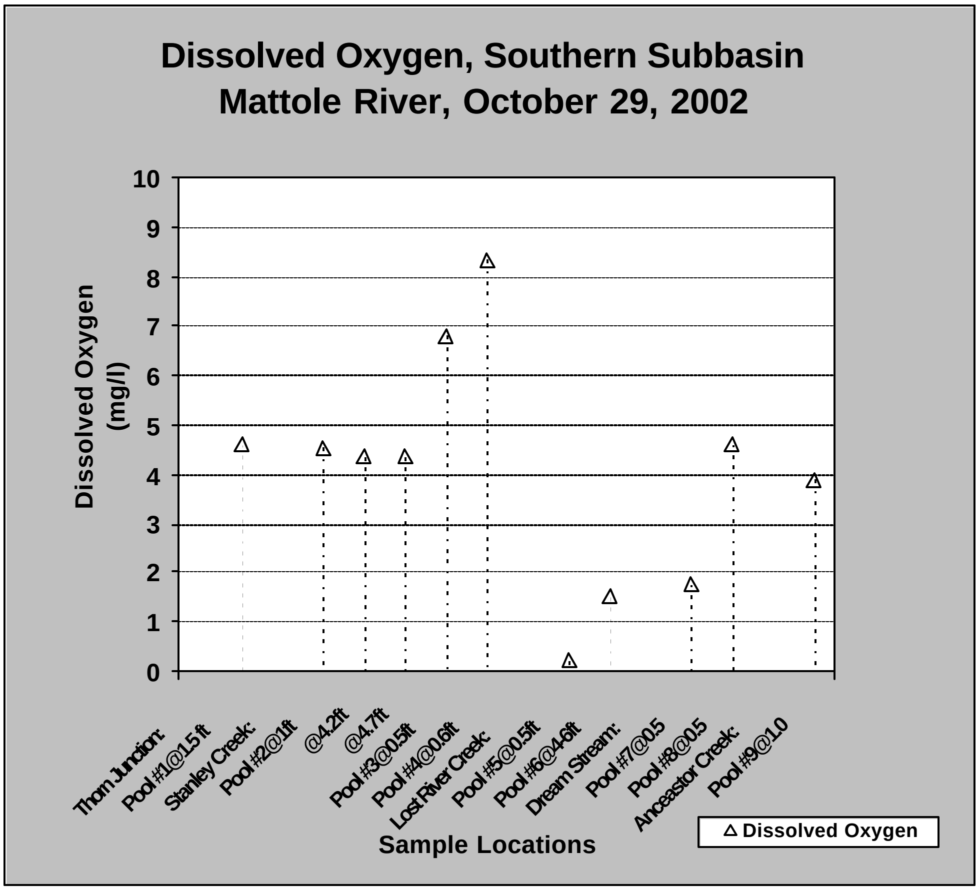

Figure 18. Dissolved oxygen, Mattole River, McKee Creek to Ancestor Creek, October 29, 2002.

Except for the above single day sampling event there was no other short or long term water quality physical-chemical data available for this subbasin. However, there is anecdotal evidence that during drought to near-drought conditions, such as those experienced in 2002, that unauthorized instream and near-stream water withdrawals are known to dewater headwater reaches of the Mattole mainstem and some of its smaller tributaries. If so, this practice will negatively impact salmonid rearing during critical, low flow summer periods (Gary Peterson, 2001). It would be difficult because of property right constraints, but closer monitoring of authorized and unauthorized water withdrawals from area streams, and possibly near-stream springs, in this portion of the Southern Subbasin may be warranted to ascertain if overdrafting is affecting the beneficial uses of water.

<u>Water Temperature</u>:
In general, the MWATs depicted in Table 15 and Figure 19 in the Southern subbasin are tightly aggregated in the high fifty to low sixty degree range. As such, the various tributaries can largely be

addressed as a group. Although a number of the MWATs are right at the upper temperature threshold of 60 ^{o}F, the majority of temperatures in many of the Southern Subbasin tributaries are within the 50-60 ^{o}F fully suitable range for coho salmon viability. Fish population data collected by the DFG and the MSG indicates that most of these tributaries support coho and other salmonid populations, and are some of the most highly productive salmonid streams of all of the Mattole River subbasins (Coastal Headwaters Association, 1983; DFG, 1986; Gary Peterson, 2001). Temperature locations referenced for the Eastern Subbasin are included as Figure 28, Map 3 at the end of this appendix.

The lower MWAT values in nearly all of the Southern Subbasin reaches sampled are probably, in part, attributable to the high canopy coverage recorded over the wetted stream channels. For example, canopy data compiled by the DFG and available in the KRIS database, indicates canopy cover in most of the sampled streams approaching 75-90% (DFG, 1986). Interestingly, Helen Barnum Creek, which had an MWAT of 56.4 ^{o}F during 2001 has the lowest percent canopy cover, approximately 65%, of all of the sampled reaches. Thompson Creek, with approximately 82% canopy coverage recorded MWATs consistently at or above 60 ^{o}F during all record years.

Preliminary CGS mapping and analysis for the NCWAP, and also past research by the MRC (MRC, 1989), indicate that most of the tributaries to the mainstem Mattole River in the Southern Subbasin occupy entrenched, narrow valleys, the orientations of which may offer additional shading from solar radiation. These geologic conditions, and dense riparian canopy cover, may combine to contribute to the lower recorded MWATs in Southern Subbasin streams.

Table 15. Maximum weekly average temperatures, various tributaries, Mattole River in the Southern Subbasin, 1996 through 2001.

Tributary	River Mile*	MWAT (F) 1996	MWAT (F) 1997	MWAT (F) 1998	MWAT (F) 1999	MWAT (F) 2001
Bridge Cr	52.1 + 0.2	63.9		65.0	59.8	60.9
Van Arkin	54 + 0.1		60.1	60.8	59.9	58.9
Baker Cr	57.6 + 0.1	61.3	60.9	61.3		58.6
Yew Cr	58.4 + 0.4	61.5	60.3	60.7	58.7	57.6
Thompson Cr	58.4 + 0.6	62.3	61.8	62.5		60.6
Helen Barnum Cr	58.7 + 0.1					56.4
Lost River Cr	58.8 + 0.5	60.3		60.9		58.4
Dream Stream	59.5 + 0.01					55.4
Ancestor Cr	60.8 + 0.2					56.7

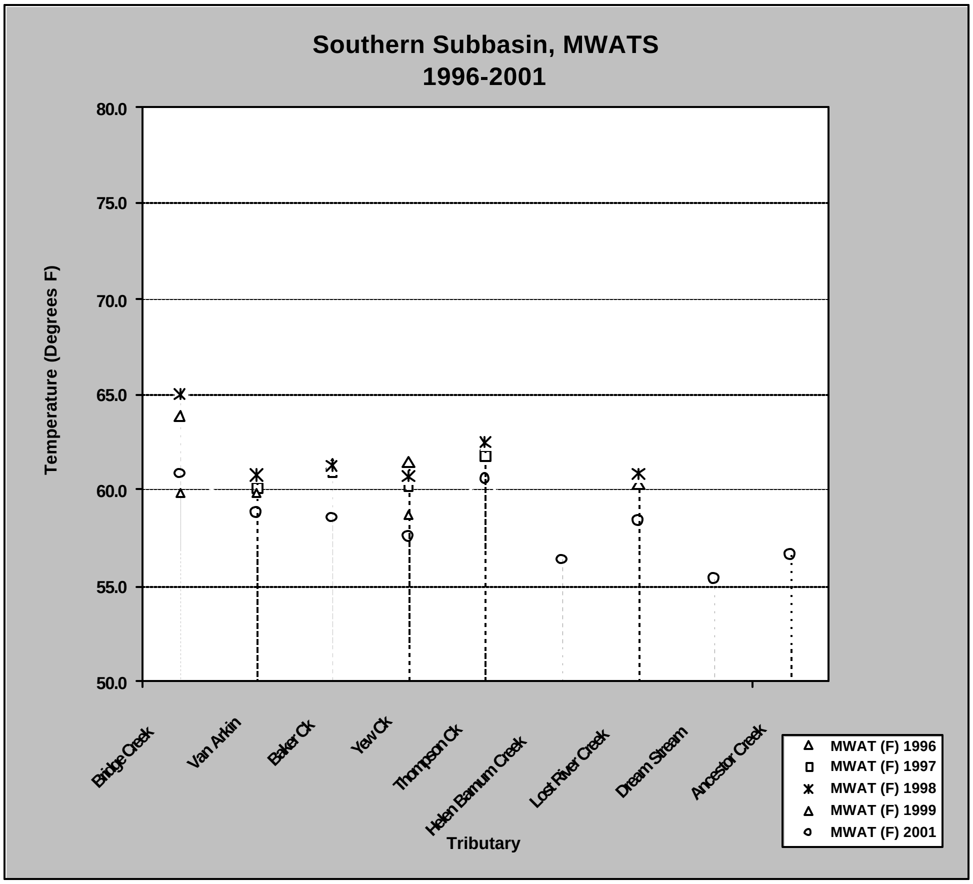

Figure 19. MWATs for nine tributaries to the Mattole River, Southern Subbasin, 1996 to 2001.

Table 16 and Figure 20 represent maximum summer temperatures in select tributaries in the Southern Subbasin. None of these tributaries had maximum summer temperatures that exceeded the critical peak lethal temperature threshold of 75 ^{o}F established for salmonid survival, however, Bridge Creek during 1998 approached the 75 ^{o}F threshold with a peak summer temperature of 72 ^{o}F.

Table 16. Maximum summer temperatures for nine tributaries, Southern Subbasin from 1996-2001.

Tributary	River Mile*	MAX (F) 1996	MAX (F) 1997	MAX (F) 1998	MAX (F) 1999	MAX (F) 2000	MAX (F) 2001
Bridge Cr	52.1+1.0	68		72	62	68.7	69.5
Vanauken Cr	54.0+0.01					64.5	62.2
Baker Cr	57.6+0.1	64	65	65	63		68.7
Yew Cr	58.4+0.2	66	63	65	62	64.2	61.6
Thompson Cr	58.4+0.2	67	64	65	65	68.7	66.1
Lost River Cr	58.8+0.01	61	61	65	59		61.2
Helen Barnum Cr	58.8+0.1						58.1
Dream Stream	60.4+0.1	57	57				57.3
Ancestor Cr	60.8+0.5	57	59				60.1

*River mile indicates locations of the confluence of the tributary from the Mattole River mouth, the + indicates distance upstream the thermograph is located from the confluence of the tributary to the Mattole mainstem. Records were available in summary form from the MSG.

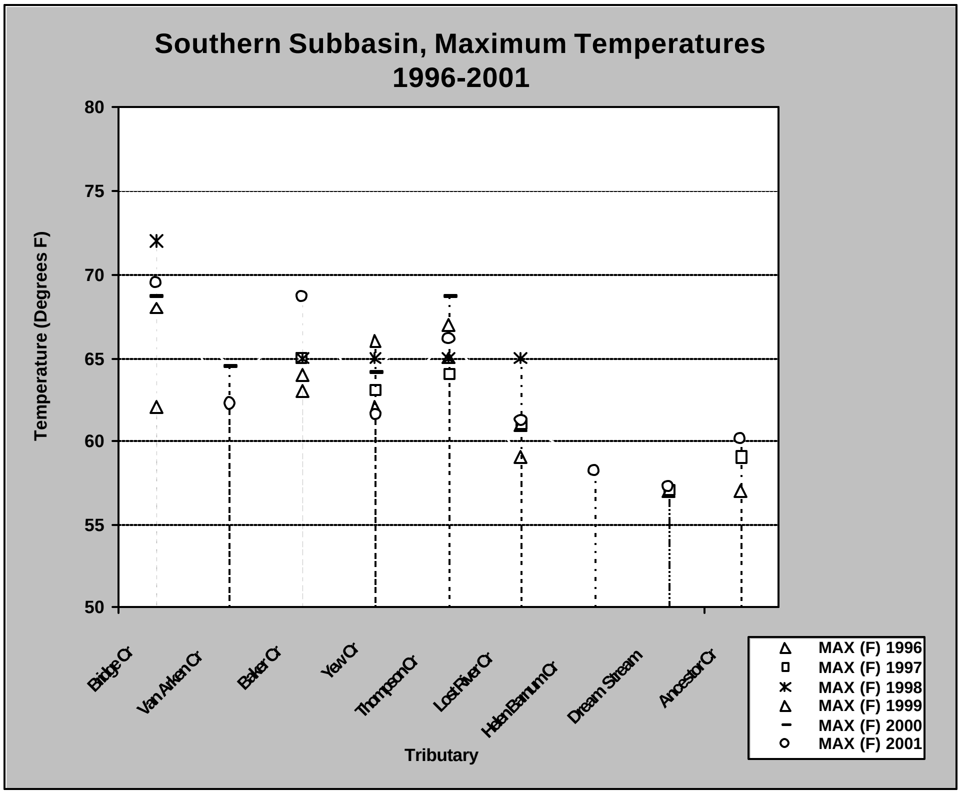

Figure 20. Maximum summer temperatures in nine tributaries to the Mattole River, Southern Subbasin, 1996 to 2001.

Sediment:

V*: The MSG collected and calculated a V* = 0.04 in Bridge Creek during 2000, included in Table 17. This is an exceptionally low value and may indicate, 1) low sediment production due to few, if any, upslope disturbances or, 2) rapid sediment transport through well armored pools that may experience high rates of scour during storms. This value is well below the mean V* < 0.21 established for the Garcia River TMDL. Knopp also collected and calculated V* values for three different watercourses, included in Table 17, during 1992 (Knopp, 1993). All of the 1992 results are above the mean V* < 0.21 established for the Garcia River TMDL but Mill Creek with a V* = 0.24 is only slightly above the Gracia River target. None of Knopp's study reaches have been repeated in the Southern Subbasin since, and, without recent V* sampling, it is impossible to determine improving and/or declining trends.

Table 17. V* for four tributaries, Southern Subbasin, 1992 and 2001.

Tributary	Year Sampled	V*
Baker Cr	1992	0.51
Bridge Cr	2001	0.04
Mill Cr	1992	0.24
Yew Cr	1992	0.45
Garcia River TMDL	N/A	< 0.21

D50: The Regional Water Board collected and determined D50 values from pebble counts for eight tributaries, represented in Table 18, in the Southern Subbasin during 2001. During 1992, Knopp also collected and determined D50s in one additional watercourse, Mill Creek, also included in Table 18. Repeat D50 measurements since 1992 were completed in two streams, Baker and Yew creeks, by the

Regional Water Board during 2001. Both Baker and Yew creeks showed slight downward shifts in D50 values from 1992 to 2001 of 6 mm and 7 mm, respectively. For comparison purposes the minimum and mean D50s averaged for all of the study sites from Knopp's 1992 study, and the standards adopted by the Garcia River TMDL, are included with those determined during the Regional Water Board's 2001 sampling efforts.

Table 18. Median particle size, D50, for nine tributaries, Southern Subbasin, 2001.

Tributary	Year Sampled	No. of Sites	Minimum D50 (mm)	Maximum D50 (mm)	Mean D50 (mm)
Baker Cr	1992	N/A	N/A	N/A	29
Baker Cr	2001	3	23	23	23
Bridge Cr	2001	2	64	66	65
Helen Barnum Cr	2001	2	12	16	14
Lost River Cr	2001	2	16	18	16
Mill Cr	1992	N/A	N/A	N/A	52
Thompson Cr	2001	1	37	37	37
Vanauken Cr	2001	3	18	39	26
Yew Cr	1992	N/A	N/A	N/A	47
Yew Cr	2001	2	27	52	40
Ancestor Cr	2001	1	17	17	16
Knopp, all	1992	18	37	183	69
Garcia River TMDL	N/A	N/A	37	N/A	69

None of the above values for those streams sampled during 1992 or 2001depicted in Table 18 meet the Garcia River TMDL target mean D50 >69 mm and, therefore, would not be protective of the COLD beneficial use established for the Garcia River. Bridge Creek is just below the TMDL threshold at D50 =65 mm. Bridge Creek, as mentioned above, also had a very low V* = 0.04. The combination of these two near or above optimal sediment metrics in Bridge Creek appear to indicate reduced upslope sediment production and lower sediment storage than the other tributaries sampled in the Southern Subbasin during 1992 and 2001.

Western Subbasin

Water Chemistry and Quality:
BLM personnel collected total and fecal coliform data in the upper South Fork Bear Creek drainage during winter, spring, and summer of 1993. Sampling was prompted by concerns that campers and recreational users of waste disposal facilities at nearby BLM managed Wailaki and Nadelos campgrounds could potentially discharge harmful coliform bacteria and other pathogens to the SFK Bear Creek. Analyses showed total and fecal coliform levels well below Regional Water Board water contact thresholds (BLM, 1995).

Water Temperature:
Squaw Creek, Honeydew Creek, and Bear Creek are the three major tributaries to the mainstem in the Western Subbasin with reliable temperature information from 1996 to 2001. Several smaller tributaries listed in Table 19, had periodic, but discontinuous summer temperature monitoring. Temperature locations referenced for the Western Subbasin are included as Figure 29, Map 4 at the end of this appendix.

Honeydew Creek and Bear Creek: Interestingly, for Honeydew Creek and Bear Creek, the two tributaries with broad temporal and spatial temperature coverage from their confluence's with the mainstem Mattole to near headwater reaches, temperature distributions nearly mirror the MWAT curve of the mainstem Mattole, as previously discussed. Again, as you move downstream from the headwater reaches and tributaries of each watercourse, MWATs are in the mid- to high 50 ^{o}F, to low 60 ^{o}F ranges, much like the upper reaches of the mainstem Mattole River. By the time Bear and Honeydew creeks reach their confluence's approximately 0.1-0.5 miles upstream from the mainstem, MWATs gradually increased to maximums of 71.9 ^{o}F at Honeydew Creek in 1999, and 71.0 ^{o}F in 1998 and 70.1 ^{o}F in 2001 for Bear Creek. For other years, MWATs in Honeydew Creek at the confluence dropped to an identical 68.9 ^{o}F during 1997 and 1998. From 1997 through 2001 Bear Creek had five MWATs ranging from 67.8 ^{o}F to 71.5 ^{o}F at two locations approxmately 0.5 to 0.6 miles upstream from the mainstem (MSG, 2001; Regional Water Board, 2001; Welsh, et al., 2001).

Except for Mill Creek during all sampled years, Stansberry Creek during 1999, the temperatures that cluster around ± 60 ^{o}F in the NFK Bear creeks during 1996 and 2001, and the SFK Bear Creek during 2001, Big Finley Creek in 1999, and Clear and Nooning creeks during 2001, all of the Western Subbasin tributaries at one time or another had temperatures that exceeded the fully suitable 50 - 60 ^{o}F MWAT range considered suitable for optimal salmonid survival. Welsh, et al., found that during snorkel dives and other coho presence surveys only Mill Creek in the Western Subbasin had populations of juvenile coho salmon (Welsh, et al., 2001). Other literature searches documented that chinook and coho salmon, and steelhead, were, or may still be present in many of the tributaries that Welsh studied, including Honeydew, Bear, Big Finley, and Squaw creeks (BLM, 1995 and 1996; MRC, 1995; Coastal Headwaters Assn., 1983; MSG, 1997).

CGS's NCWAP fluvial geomorphologic assessment states that the Western Subbasin is characterized by a highly variable percentage of disturbed channel and stream bank erosion throughout the subbasin, and that some of those areas include portions of streams within the Honeydew and Bear creeks planning watersheds. Additionally, in reviewing the BLM watershed assessments for Bear Creek (BLM, 1995) and Honeydew Creek (BLM, 1996) it was stated that the lower reaches of both streams have open, alluvial floodplains with poor streamside canopy coverage. Similar conditions exist for the lower reaches of the mainstem Mattole that allow high solar radiation inputs to reach unprotected stream channels. The open, disturbed channel configurations in the mainstems of the Mattole River, and Honeydew and Bear creeks are reflected in the higher MWATs and peak maximum temperatures for all three watercourses.

Squaw Creek: Except during 1999 when an MWAT of 63.6^{o}F was reported, Squaw Creek had MWATS that ranged from 69.1 ^{o}F, 69.5 ^{o}F, and 70.0 ^{o}F during 1996, 1997, and 1998, respectively (MSG, 2001; Welsh, 2001). For all available records, Squaw Creek only had one field temperature site located approximately 0.1 mile upstream from its confluence with the Mattole River. Without additional records for upstream reaches it would be difficult to assess the entire Squaw Creek watershed. It does appear that similar fluvial and habitat conditions may exist for some distance upstream from the confluence of Squaw Creek with the Mattole River as those in Bear and Honeydew creeks for similar elevated water temperatures to be recorded. However, specific fluvial geomorphology analysis for Squaw Creek was not provided in CGS's NCWAP assessment.

Nooning Creek: The Regional Water Board's MWAT of 57.8 ^{o}F during its 2001 sampling period is the only available MWAT for Nooning Creek. For this year only this temperature is within temperature range of 50-60 ^{o}F considered suitable for coho salmon growth. Additional temperature records, spatially and temporally distributed, would be desirable to more fully assess upstream conditions in Nooning Creek.

Mill Creek-RM 2.9: Mill Creek temperature records are available for 1997, 1999, 2001, and in Welsh's multi-year (1998-1999) study, and during those years MWATs are consistently within one degree of 58 ^{o}F. The MSG's summary data also recorded an MWAT during 1998 for Mill Creek of 66.4 ^{o}F, however, the same thermograph entry had a maximum summer temperature of ~100 ^{o}F. The 1998 temperatures were deemed inconsistent and unusable for that record year and are not included in this report.

Mill Creek's water temperatures are supportive of a small population of coho salmon (BLM, 2001; Welsh, 2001), The BLM reported that riparian tree species are primarily red alder with a dense, shrubby undergrowth. Perhaps the combination of an excellent streamside riparian canopy coupled with the effects of cooler marine weather intrusions into the Mill Creek watershed create conditions ideally suited to sustain long term coho salmon populations.

Stansberry Creek: Stansberry Creek had an elevated MWAT of 63.5 ^{o}F during 1998 and, like Mill Creek, more "normal" temperatures for this tributary appear to be in the 57-58 ^{o}F range. Marine weather intrusions may also moderate the stream water temperature in Stansberry Creek. There were no coho salmon observed during 1998-1999 dive surveys, perhaps due to lack of adequate spawning habitat, even though the 58.2 ^{o}F MWATs during 1999 was within the lower and upper limits for optimal coho growth.

The following tables and figures visually represent the above discussions concerning temperature relationships in the Western Subbasin.

Table 19. Maximum weekly average temperatures for various tributaries to the Mattole River, Western Subbasin, 1996 through 2001.

Tributary	River Mile	MWAT (F) 1996	MWAT (F) 1997	MWAT (F) 1998	MWAT (F) 1999	MWAT (F) 2001
Stansberry Creek	1.3 + 0.1			63.5	58.2	
Mill Creek-RM 2.8	2.8 + 0.5	57.7			58.4	57.7
Clear Cr	6.1 +0.2					59.1
Squaw Ck	15.0 + 0.1	69.1	69.5	70.0	63.5	
Saunders Cr	19.9 +0.3					60.1
Woods Cr	24.1 +0.1					60.8
Honeydew Cr	26.6 + 0.5		68.9	68.9	71.9	
Honeydew Cr LwrUS	26.5 + 3.2			62.9		
Honeydew Cr Mid-US	26.5 + 4.2			62.6		
HoneyDew Upper-US	26.5 + 4.8			63.9		
Honeydew US Lower EFK	26.5 +3.0 +0.2			64.0		
HoneyDew WFK	26.5 +4.2 +0.2			62.6		
Honeydew US Upper EFK	26.5 +4.5 +0.3			61.1		
Bear Creek MS	42.8 + 0.01					70.1
Bear Creek MS (A)	42.8 + 0.0005		67.8	71.0	70.1	69.4
Bear Creek MS (B)	42.8 + 0.6			71.5		
Bear Creek Upstream	42.8 + 5.0		64.7			
Bear Ck Upper Upstream	42.8 + 6.6	64.7	60.5			
Bear Ck LNFK	42.8 + 7.1	60.0				61.5
Bear Ck SFK	42.8 + 5.1	64.2				60.9
Big Finley Creek	47.4 + 0.1				60.3	59.2
Nooning Creek	50.2 + 0.01					57.8

*River miles and distances upstream in tributaries, if applicable, are listed after the watercourse name, otherwise temperature locations are within 0.1 mile from the confluence with the Mattole mainstem.

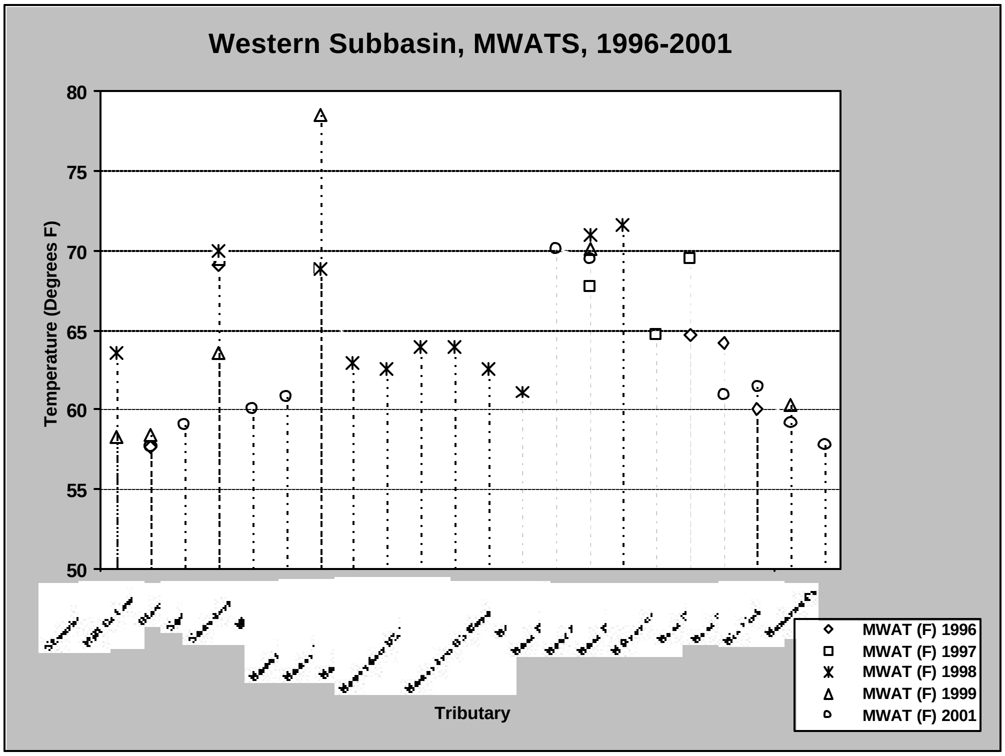

Figure 21. Maximum weekly average temperatures for various tributaries to the Mattole River, Western Subbasin, 1996 to 2001.

Table 20. Maximum summer temperatures for various tributaries to the Mattole River, Western Subbasin, 1996-2001.

Tributary	River Mile*	MAX (F) 1996	MAX (F) 1997	MAX (F) 1998	MAX (F) 1999	MAX (F) 2000	MAX (F) 2001
Stansberry Cr	1.3+0.1		65	62	62		
Mill Cr	2.8+0.5	57	64	61	68		59.3
Clear Cr	6.1+0.2					62.2	
Squaw Cr	15+0.1	77	74	75	72		
Squaw Cr-upstr	15+2.0		67				
Woods Cr	24.1+0.1					67.4	
Honeydew	26.6+0.5	76	80	80	79		
Bear Cr	42.8+0.6	68	76	78		71.1	76.8
Bear Cr, upstr	42.8+5.0	71	72				
NFK Bear Cr	42.8+5.1		74	72			66.6
SFK Bear Cr	42.8+5.1	69	69				65.4
Little Finley Cr	46.7+0.1	72	72				
Big Finley Cr	47.5+0.1			63	61		61.8
Nooning Cr	50.2+0.01						61.2

*River mile indicates locations of the confluence of the tributary from the Mattole River mouth, the + indicates distance upstream the thermograph is located from the confluence of the tributary to the Mattole mainstem, 1996-2000.

Like the elevated MWATs for the downstream reaches of Honeydew and Bear creeks, similar elevated maximum temperatures are noted in these same reaches. The critical peak lethal temperature threshold of 75 °F established for salmonid survival was exceeded in Squaw Creek during 1996 and equaled in 1998. It was exceeded all years in Honeydew Creek, and in Bear Creek during 1997, 1998, and 2001. All of these peak maximum temperature exceedences were measured within 0.6 miles from each stream's confluence with the Mattole River.

The upstream reaches of Bear Creek did not exceed the maximum 75 °F lethal temperature threshold during any of the years of record, although the North Fork Bear Creek was close at 74 °F. Data was not available to evaluate upstream reaches of Honeydew Creek. There was also insufficient data to adequately evaluate temperature trends in the upstream reaches of Clear, Woods, and Nooning creeks. A maximum summer temperature was available during 1997 for Squaw Creek two miles upstream that, at 67 °F, did not exceed the critical peak lethal temperature threshold of 75 °F established for salmonid survival. An MWAT for this same location in Squaw Creek was not available.

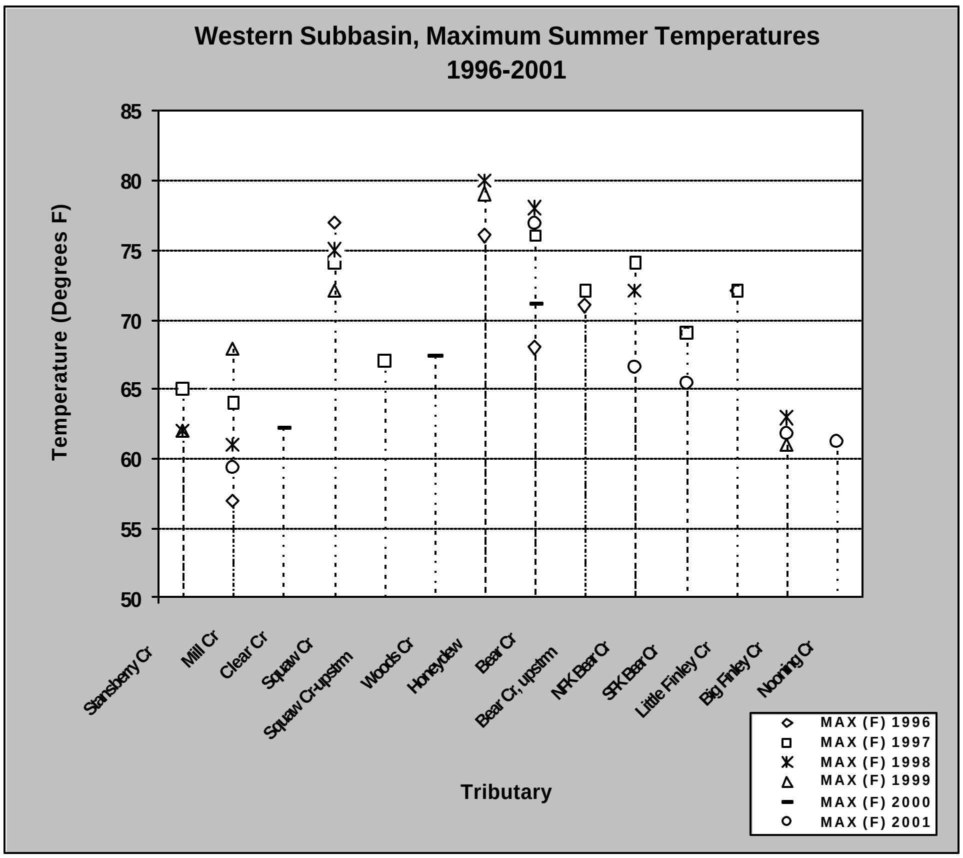

Figure 22. Maximum summer temperatures in various tributaries in the Western Subbasin, 1996 to 2001.

Thermal Infrared Temperatures: In the Western Subbasin on July 20, 2001, TIR temperature imaging surveys were used to derive point-in-time, median surface water temperatures for the mainstems of Bear Creek, Honeydew Creek, and Squaw Creek. Bear Creek was flown from the Mattole River to the confluence's of the North and South Forks ("the forks"), a distance of approximately 6.9 miles. Mainstem Honeydew Creek was surveyed for approximately 5.7 miles upstream from the Mattole River, and Squaw Creek was surveyed upstream from the mouth to the headwaters, a distance of approximately 11.7 miles (Watershed Sciences, 2001).

Bear Creek TIR: Figure 23, below, is the TIR derived temperature profile for the mainstem of Bear Creek flown from 1:55 to 2:11 p.m., a time interval of 16 minutes, on July 20, 2001. In general, median surface water temperatures increase relatively rapidly from "the forks" at approximately RM 6.9, to RM 6.1, then fluctuate between approximately 63 ^{o}F and 66 ^{o}F until RM 1.4. From RM 1.4 to approximately RM 0.9, the surface temperature spikes rapidly from approximately 65 ^{o}F to a maximum 70 ^{o}F. This steep temperature rise is the reach where Bear Creek transitions from a canyon-like morphology to an open, aggraded floodplain until its confluence with the Mattole River. It should be noted that the 70 ^{o}F median surface water temperature during the day of the TIR profile did not exceed the critical peak lethal temperature threshold of 75 ^{o}F established for salmonid survival. However, thermographs placed in Bear Creek approximately 0.6 miles upstream from the Mattole River (refer to Table 20 and associated discussion) exceeded the 75 ^{o}F lethal salmonid temperature threshold during available record years of 1997, 1998, and 2001. The 2001 thermograph maximum was recorded on August 8, shortly after the TIR flyover. As mentioned previously, the critical peak lethal temperature was not exceeded in Bear Creek at RM 5 during the two years of available thermograph records, nor was it exceeded on the July 20, 2001 flyover. In general, the TIR temperature profiles closely parallel those derived from thermographs, however, the thermograph data was only available at two points along Bear Creek.

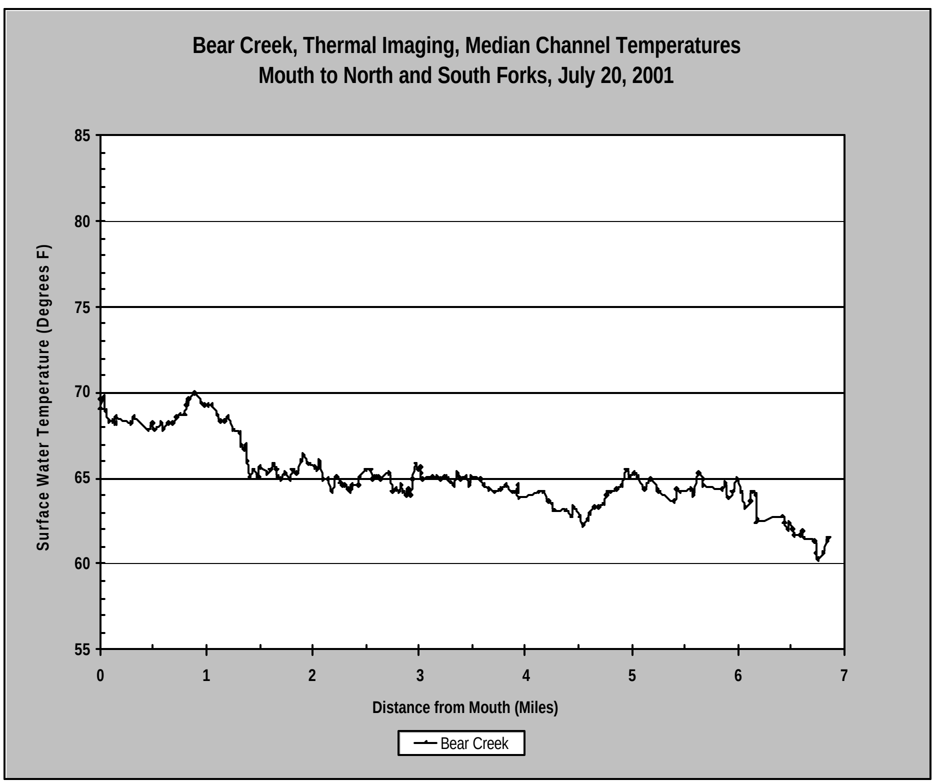

Figure 23. Median surface water temperatures, thermal infrared imaging, mainstem Bear Creek, July 20, 2001.

Honeydew Creek TIR: As noted in Figure 23 for Honeydew Creek, median surface water temperatures in the TIR profile gradually increased in a downstream direction beginning with a relatively cool 57.6 ^{o}F recorded at the most upstream end of the flyover. From approximately RM 3.2 to the mouth, temperatures increased rapidly, reaching a maximum near 71 ^{o}F approximately 0.5 miles from the mouth. Similarly, Honeydew Creek, like Bear Creek, assumes a more open, alluvial floodplain near the

3 mile reach until its confluence with the Mattole River, reflected in higher maximum surface temperatures at the downstream reaches of both watercourses compared to headwater reaches.

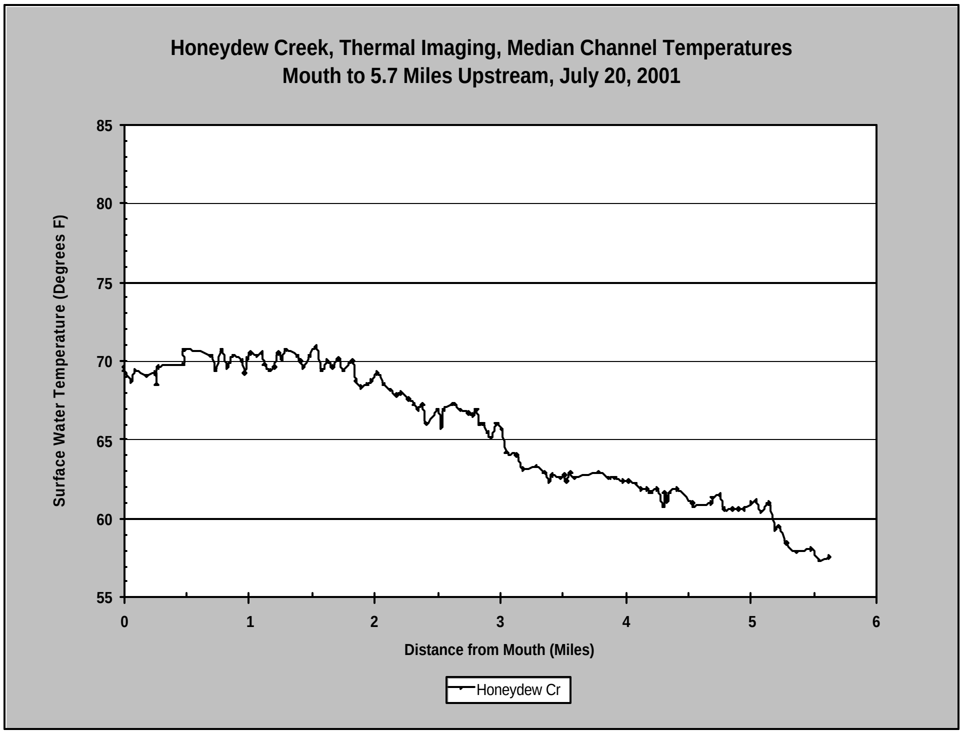

Figure 24. Median surface water temperatures, thermal infrared imaging, mainstem Honeydew Creek, July 20, 2001.

Squaw Creek TIR: Squaw Creek (Figure 25), just before entering the Mattole River at 70 ^{o}F, was 6.8 ^{o}F cooler than the mainstem, which was 76.8 ^{o}F. From the mouth upstream to approximately RMs 0.6-0.7, median surface water temperatures increased to 73.2 ^{o}F before steadily declining to a minimum 55.6 ^{o}F at the upper extent of the survey at RM 11.7. Like Honeydew and Bear creeks, the video imaging along Squaw Creek's profile recorded an open, channel morphology until the upper reaches became masked, and likely cooled, by riparian vegetation. Several localized drops in temperature are graphically visible in Figure 25 that may be from cooler water seeps, springs or small tributaries discharging to Squaw Creek, however, the sources of the cooling were not visible during the flyover and subsequent image analysis (Watershed Sciences, 2002).

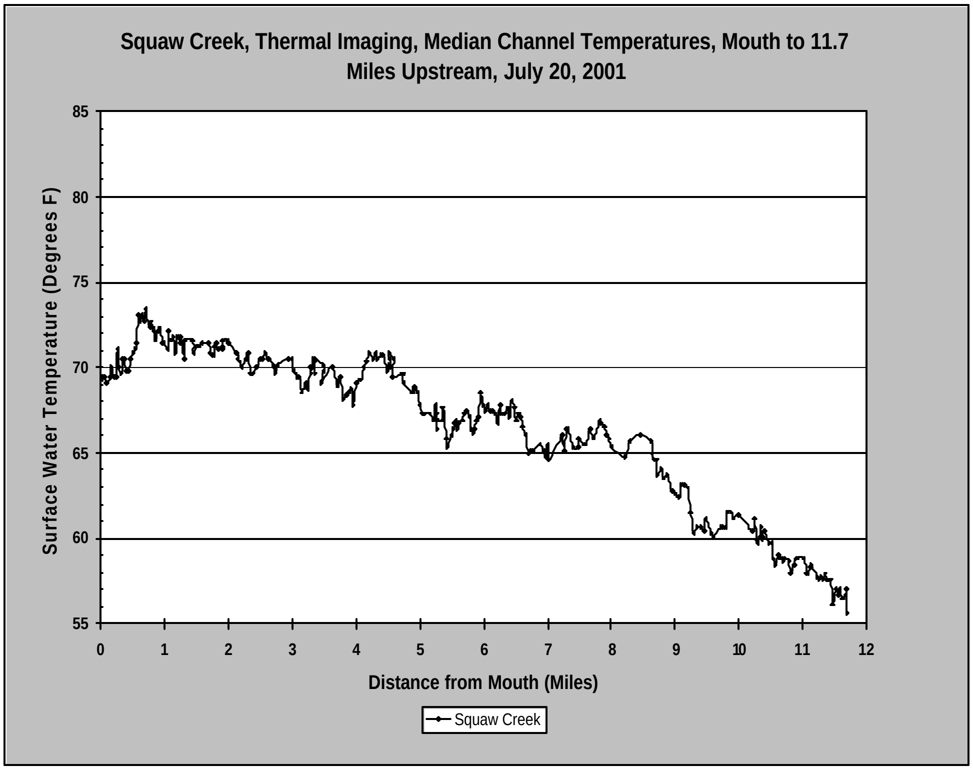

Figure 25. Median surface water temperatures, thermal infrared imaging, mainstem Squaw Creek, July 20, 2001.

DFG Summer Temperatures: In the Western Subbasin, from August 19 through September 20, 2001, Squaw Creek was the only watercourse that the DFG collected water temperature data. As Table 22 shows Squaw Creek exceeded the preferred MWAT range for the various salmonid species during that time period and, in all likeihood, also would have exceeded critical temperature thresholds earlier in the summer. Because there is only a single temperature location a chart for Squaw Creek is not included.

Table 21. Department of Fish and Game, MWAT and maximum summer temperature, Squaw Creek, Western Subbasin, mid-August through mid-October 2001.

Location	Hobo Placement	MWAT (F) 2001	MAX (F) 2001
Squaw Creek	~400 ft upstream from Mattole River	65.5	69.2

Sediment:

V*: V* was collected and calculated in the following Western Subbasin tributaries during 2000 by the MSG: Mill Creek, V* = 0.26; Squaw Creek, V* = 0.24; Honeydew Creek, V* = 0.22. All of these values were indicative of low rates of residual pool filling. The MSG data shows that the recommended mean V* <0.21, established for the Garcia River TMDL as being protective of the habitat of cold water fish described in the COLD beneficial use was exceeded, but only slightly, in all three of the above streams.

V* was also collected in 1992 under a cooperative project between the Regional Water Board and the California Department of Forestry (Knopp, 1993) in the North Fork Bear Creek and the West Fork Honeydew Creek. The NFK Bear Creek had a V* = 0.25, and the West Fork Honeydew Creek V* = 0.10. Both reaches had similar stream gradients of 2.7% and 2.4%, respectively. Again, using the Garcia River TMDL as a reference for discussion, the NFK Bear Creek is slightly above the recommended minimum target of mean V* < 0.21, and the WFK Honeydew Creek is well below the target. Bear Creek's V* result is indicative of low to moderate residual pool sediment filling, and the WFK Honeydew Creek's is indicative of very little residual pool filling from upslope-upstream land use and/or natural disturbances.

For Honeydew Creek it is difficult to compare the V* results from the MSG in 2000, to those of Knopp in 1992, as both data sets were spatially and temporally isolated. Except for Bear Trap Creek, the MSG's sample points in Honeydew Creek were collected in the mainstem downstream from all other tributaries. Knopp's V* locations were in the West Fork approximately two miles upstream from the MSG's sampling efforts. However, there does appear to be a slightly additive effect of increased residual pool filling in the mainstem, at V* = 0.13, compared to the upstream location of the West Fork at V* = 0.10 but the difference of 0.03 is not significant between the two sample points. It is difficult to conclude but it appears that excess sediment, for this metric, is not impairing Honeydew Creek as both results are below, by approximately half, the Garcia River TMDL for V* = 0.21 and would be protective of the COLD beneficial use if this numeric target were applicable to the Mattole River.

D50: Knopp recorded a D50 = 105.9 mm for the West Fork Honeydew Creek. This exceeded the mean D50 > 69 mm established for the Garcia River TMDL and, at that time, was protective of the COLD beneficial use if this numeric target were applicable to the Mattole River.

There were no repeat or new sediment sampling efforts by the MSG or other parties in the North Fork Bear Creek since Knopp's 1992 study for which he determined a mean D50 = 61.9 mm. This value is less than the D50 > 69 mm established for the Garcia River TMDL and, therefore, would not have been protective of the COLD beneficial use. Until new data is collected there are no conclusions or comparisons that can be made concerning recent trends, beneficial or otherwise, that may be occurring in the North Fork Bear Creek watershed.

In Nooning Creek the Regional Water Board collected and analyzed pebble counts on two riffles and calculated a mean D50 = 36.5 mm during 2001. This value is under the recommended target mean D50 >69 mm established for the Garcia River TMDL and would not have been protective of the COLD beneficial use if this numeric target were applicable to this Mattole River tributary. The minimum and maximum mean D50 for the two riffles was 34 mm and 39 mm, respectively.

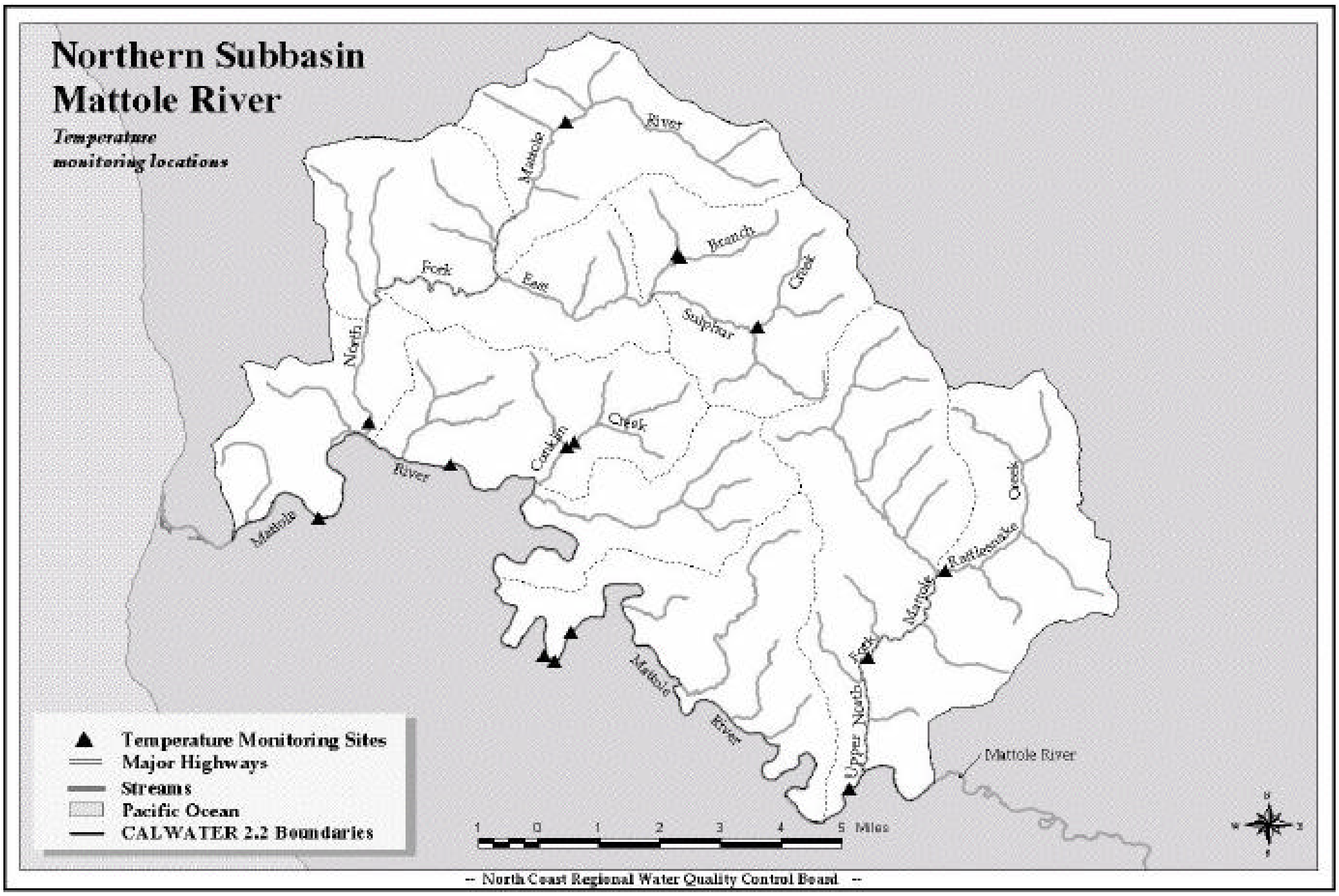

Figure 26. Map 1: Northern Subbasin and Mattole River mainstem temperature monitoring locations, all involved parties, 1996-2001.

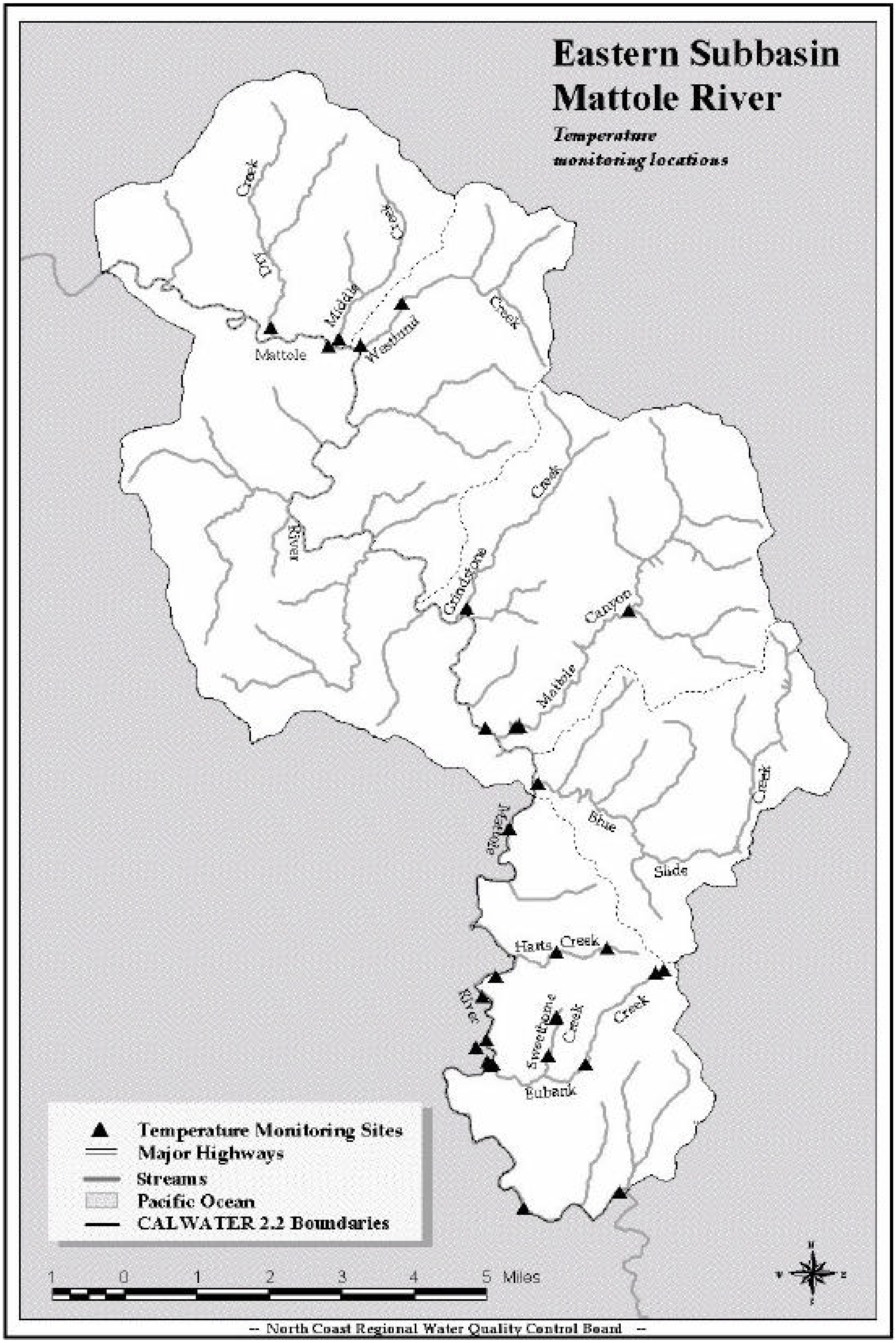

Figure 27. Map 2: Eastern Subbasin and Mattole River mainstem temperature monitoring locations, all involved parties, 1996-2001.

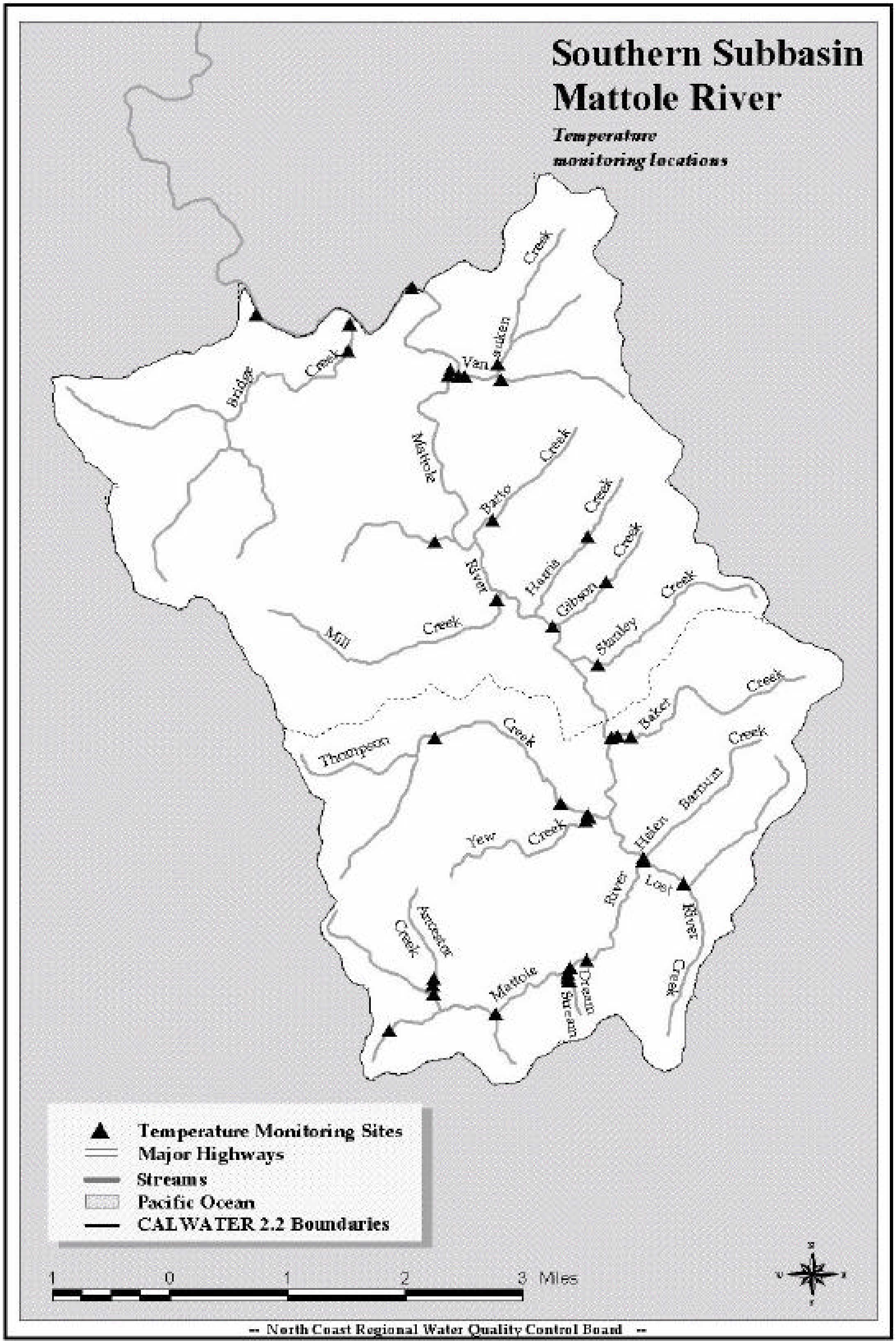

Figure 28. Map 3: Southern Subbasin and Mattole River mainstem temperature monitoring locations, all involved parties, 1996-2001.

Figure 29. Map 4: Western Subbasin and Mattole River mainstem temperature monitoring locations, all involved parties, 1996-2001.

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